UNIVERSITY OF MICHIGAN
SEP 19 1956
ENGINEERING LIBRARY

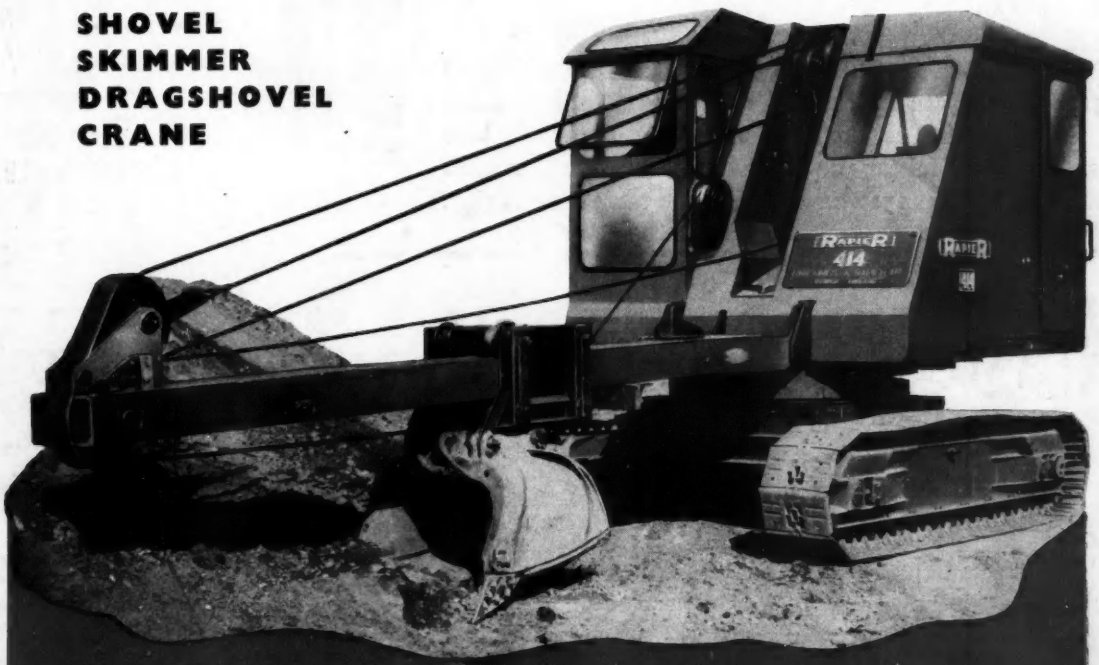
The Engineer

AUGUST 31, 1956 28 ESSEX ST., STRAND, LONDON, W.C.2. TWO SHILLINGS

The NEW RAPIER 414
with the 12 ★ improvements

3/8 cu. yd.
four-purpose equipment

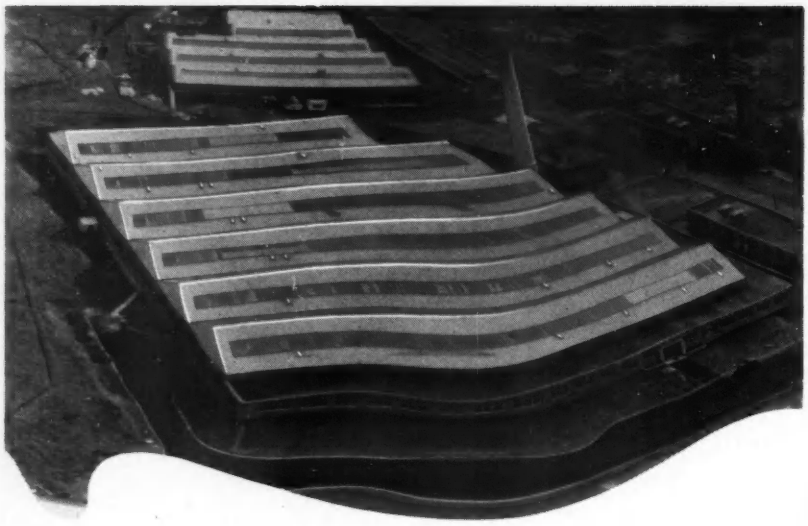
SHOVEL
SKIMMER
DRAGSHOVEL
CRANE



★ Easier track adjustment
★ Digging lock controlled from cab
★ Large crawlers—lower ground pressure
★ Ball and roller bearings throughout superstructure machinery
★ More powerful diesel engine
★ Greater stability
★ Longer boom for dragline
★ Reduced rope wear—larger pulleys
★ New cab—improved vision and weather protection
★ More ground clearance—travel gears in oil bath
★ Less wear on drag rope—new self-aligning fairlead
★ Larger bearings and improved sealing on track rollers

Also Dragline, Grab, Crane and Piledriver
Early delivery

RANSOMES & RAPIER LTD · IPSWICH · ENGLAND



Make your factory flexible by the Croid-Cooper method...

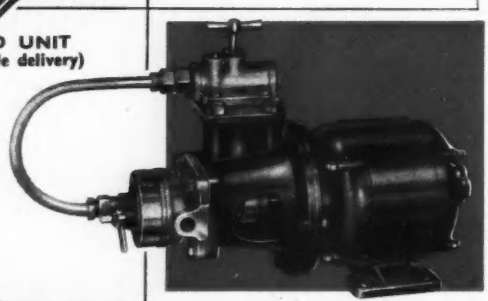
CROID 65
MACHINE FIXING GLUE
COOPERS FELT

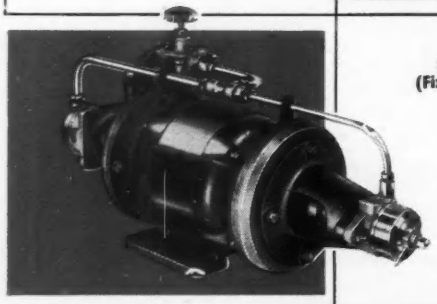
With the Croid-Cooper system of machinery installation your layouts can be changed overnight without impeding production. Each machine is simply stuck down on a felt base which absorbs vibration. Holding power is 50 lbs to the square inch, so the machine stays put as long as you want it. Send for more details today.

COOPER & CO (B'HAM) LTD · BRYNMAWR · BRECONSHIR
Tel.: Brynmawr 312

STANDARD UNIT
(Fixed or variable delivery)

MOTORISED UNIT
(Fixed or variable delivery)





SPECIAL UNIT
(Fixed or variable delivery)

This is why Savery Hydraulic Pumps have it all ways

SOME PROVED APPLICATIONS

Hydraulic feeds in machine tools, textile machinery, drilling equipment, test rigs, e
Lifting gear in mechanical handling.
Hydraulic equipment in aircraft (80,000 supplied to aircraft industry).
Hydraulic pressure in testing machines.
Metering and mixing equipment.
Pressure lubrication.
Oil burner feed equipment.

Write for further details to

Thomas Savery Pump
LTD.
BRACEBRIDGE ST · BIRMINGHAM 6 *Tel: ASTON CROSS*

THE ENGINEER

VOL. 202 No. 5249 AUGUST 31, 1956

CONTENTS

LEADING ARTICLES—
Never Be Short of Labour 289
Engineers and Physicists 290

ARTICLES—
British Association's Sheffield Meeting 291
Building Research 291
Combined Stress Creep Fracture of a Commercial Copper at 250 deg. Cent. No. II. (Illus.) 299
Continuous Carburising. (Illus.)... ... 308
Cooling System for Weaving Shed ... 310
Engravings of 1874... 306
Further French Locomotive Experiences. No. IV. (Illus.)... 292
High-Energy Spark Ignition Equipment for Oil Burners. (Illus.) 310
Irradiation Laboratory. (Illus.) 309
Mr. Oliver Thornycroft, C.B. 291
New Turbine Steamers for Heysham–Belfast Service. (Illus.) 307
Physics and Technology 297
Reactor Conference at Harwell 291
Rectifier Arc-Welding Set. (Illus.) ... 310
Road Improvement at Portsmouth ... 291
Rural Industries 291
Twentieth-Century Man Against Antarctica 296
Wire Rope Works... 309
100 Years Ago... 290

METALLURGICAL TOPICS 302

CONTINENTAL SECTION—
Italian Oil and Gas Industry. No. I. (Illus.) 312

AMERICAN SECTION—
Sea Water Evaporators at the Morro Bay Steam Power Station. (Illus.) 315
Erection of Great Egg Bay Bridge Superstructure. (Illus.)... 317
Semi-Conductor Resistivity Test Set ... 317

LETTERS AND LITERATURE 304

NEWS AND NOTES—
British Patent Specifications. (Illus.)... 319
British Standards Institution 320
Catalogues and Brochures 320
Forthcoming Engagements 320
Industrial and Labour Notes... 311
Launches and Trial Trips 320
Personal and Business 318

NEVER BE SHORT OF LABOUR

Last week-end our Editor, whilst trout fishing in Hampshire, fell into conversation with the farmer upon whose land he was walking. The farmer had lived off that land for nearly forty years and his father had been a farmer before him. He remarked at one stage of the conversation that when he first took over the farm his father had given him the advice "Never be short of labour about your farm if you want to prosper." He had prospered by heeding that advice. But it was advice that could no longer be followed. Labour had become too expensive. Whereas before the war he had never had less than twelve men about the farm, now he had four and would like to reduce it to three. Mechanisation had been the answer to high wages. He expressed in that way and in relation to a simple unchanging layout of fields something that has equally been happening over the decades in the engineering and other industries. It is not primarily evil and grabbing masters who introduce high production machinery into their works in order to multiply their already inflated profits as more rabid socialists would like to think; the really effective factor in encouraging mechanisation is the hungry demand of workers for higher wages, wages that can only be paid by reducing the number of workers per unit of output. Perhaps there may have been a time when a retiring chairman could say to his successor, "Never be short of labour in the factory if you want to prosper." That advice certainly does not run to-day. Labour is something to be done without if practicably possible. Unquestionably the reason why firms of various kinds—not only those accustomed to mass production methods—are now interesting themselves in the possibilities of automation is that since the war unions have become accustomed to pressing annually for substantial advances in wage rates. Only by finding a means of increasing output per unit of the labour force can firms now hope to keep their prices competitive in world markets.

The point is one, we think, that is not fully appreciated by the trade unions. In the General Council's report of the Trades Union Congress, published last week, there is a lengthy, interesting and well-balanced survey of the prospects for automation and its effects upon labour. But there is nowhere clearly expressed in that survey the concept that the unions have themselves made automation economically practicable and economically good sense. If wages were not already high the capital cost of automation would not be justified; because wages are high and rising higher, automation has become essential. Rightly it is stressed in the report that the coming of automation is bound to put a strain on industrial relations machinery. Over the country taken as a whole its introduction may be relatively slow. But in individual factories the change may be quite sudden. The unions, remarks the report, would like to see automation being introduced "not so fast as to put a breaking strain on the industrial relations machinery" nor "so slow as to jeopardise industry's competitive efficiency and thereby threaten employment." But the compilers of the report do not seem to have seen clearly that the unions themselves can influence the rate of its introduction by the wages policies they pursue. If they press too harshly for increased wages then industry, in the teeth of union resistance, will be forced to introduce it more rapidly than the unions, on the grounds of preventing human unhappiness, will desire. For though at home increased production costs due to higher wages can be passed on to the consumer (though only by adding to inflation) abroad competitive power must be maintained in export markets. Indeed, the rate at which automation is introduced in this country is not solely something for this country to decide for itself. The rate at which other countries introduce it will also be an influencing factor.

The report touches upon a number of other factors. It is emphasised, for example, that when automation is to be introduced there should be prior consultation with the unions involved. But unfortunately consultation does not necessarily lead to agreement. Even managements that fully sympathise with unions' views may be forced by economic circumstances to take actions that the unions, for human reasons, feel impelled to resist. Wisdom and restraint will be needed on both sides, but neither are qualities that human beings easily acquire! In an expanding industry it may well prove possible to find alternative employment within the industry, if not in the firm itself, when a factory is re-equipped. But there are quite a number of industries, to which the techniques of automation are applicable, that cannot be expected to expand. Compensation for those made redundant is discussed in the report. Unwelcome though it may be, industrial firms have clearly to face the possibility that unions will insist upon the principle. There is, too, the vexed and unhappy problem of change in the demand for skills that may be brought about. Young men can be retrained in new skills; but what happens to the old? In its discussions of these and other factors the report is studiously moderate in tone. But the General Council is almost invariably more moderate than the constituent unions of the T.U.C. Unfortunately, therefore, it cannot be taken for granted that any union whose members are affected by automation will be as reasonable. The T.U.C. Council has

cast all Luddite thinking aside. But can it really be hoped that individual trade union leaders and, even more so, shop stewards on the factory floor, will perceive as clearly that the benefit to the nation as a whole must outweigh any inconvenience or even unhappiness that the coming of automation may bring to individual workers ? That surely is too much to expect ; the more so, therefore, must managements be prepared to show tolerance and patience when new plants and processes are introduced into a factory.

ENGINEERS AND PHYSICISTS

It is astonishingly difficult to distinguish in words, as Sir George Thomson tried to distinguish in his presidential address yesterday to Section A of the British Association in Sheffield, between the work of physicists and engineers. No engineer who reads Sir George's words will, we think, be satisfied that he has really done justice to the work of engineers ; any more probably than a physicist would feel quite happy about an engineer's description of his work. Rightly, Sir George rejected as superficial the idea that " physics is the theory of engineering and that engineering is applied physics." In how many university common rooms, we wonder, has that view been arrogantly advanced and been as scornfully and indignantly rejected ? But, it is not wholly true that " fundamentally the engineer ranks with the artist, his job is to make a design—that is, an organic whole—and his theory helps him rather as perspective helped the artists of a by-gone age." For true as that statement may be of designers, there are numberless engineers concerned with running and maintenance and manufacture who have very little to do with design except to criticise it, often adversely ! Again, it is so very easy, when trying to define the difference, inadvertently to raise the hackles of one party or the other. Engineers will resent the suggestion that it is just their job to " tidy up " things initially designed by the physicist. We hasten to add that when the words are read within the context of the paragraph that contains them it is obvious that Sir George had no intention of offending. The truth may be that it is very much more difficult to define what an engineer does than to define the work of a physicist. There are so many differing kinds of engineers, and though there is no doubt at all that, however apparently different their jobs, all engineers have something in common, it is not at all easy to pin-point what it is. One can only make the thoroughly woolly and unsatisfactory statement that it is an attitude of mind ; hardly a helpful answer to an earnest inquirer !

Engineering is, of course, applied physics ; but it is so much more besides. For there are engineering discoveries to be made. In the nineteenth century, for example, engineers took a great interest in mechanisms of various kinds probably because manufacturing methods were making possible the construction of a diversity of designs. The physical basis, the mere " mechanics " of these machines could easily be perceived. What the engineer had to discover was the efficiency with which they operated in practice and what were the effects upon them of wear and tear. Again, engineers have had to discover for themselves a great deal about friction and lubrication and the frictional characteristics of differing materials in contact. Indeed, as in many other fields, it has been because the engineer has directed attention to that field that the physicist has really started to inquire into it fundamentally and very much of the work now being done is being carried out not so much by those with a physicist's training as by engineers turned physicists for the purpose. Even where it can be seen most clearly that the engineer is founding his work upon fundamentals discovered by physicists it also has to be observed that the engineer has to make certain allowances. Theory, in general, applies to the behaviour of " ideal " materials. In practice allowance has to be made for divergencies of behaviour from the ideal. These divergencies are often so important in practice that engineers, by inquiring into them often prove to be advancing the boundaries of physical knowledge alongside the physicist, filling in gaps that may seem of little interest to the latter. Again, it is a point to which Sir George gave glancing reference, very often engineers are accustomed to designing structures or machines, constructing them, and operating them to meet specified conditions despite a lack of exact physical knowledge about many of the factors involved. Large turbo-generators were built and satisfactorily operated at high pressures and temperatures long before steam tables had been extended to cover such conditions. To this day engineers allow without difficulty for the creep of metals despite lack of any complete physical understanding of the phenomenon.

Physicists have particularly come into their own in the newer electrical and electronics industries where the physical basis of the work of engineers is very clearly related to actual practice. In other fields, engineers would be delighted to have some more exact basis to work upon. Indeed, physicists, and even more so engineers trained in scientific method at a university or college, are penetrating into older established engineering industries because they are able, often by appealing to first principles, to provide a more exact basis for calculation or design, or to suggest new methods of approach. But, basically, an engineer must be prepared to design, make or operate a piece of equipment in the absence of full or exact information about many of the important factors involved. The physicist can only be satisfied by reaching full understanding, however long it takes. The engineer must feel himself happily placed if he can determine with any exactitude merely the limits, maximum and minimum, within which a particular stress or temperature or rate of wear or other factor is likely to lie. Sometimes that information can be acquired by a limited series of laboratory experiments or a limited number of observations in nature. If the results can then be expressed by some kind of formula applicable over a limited range and capable of extrapolation cautiously beyond that range, so much the better. If they cannot, then over the years and through experience of failure as well as success, codes of good practice must be built up until such time as a fuller understanding can be reached. Technical ability is a valuable possession to an engineer ; but even more valuable is the possession of good sense and good judgment.

The Engineer

100 Years Ago

(AUGUST 29, 1856)

" BESSEMER'S PROCESS "

" There are no signs of reaction ! Bessemer continues the lion of the day. The public mind continues in the same state of blazing excitement, paralleled only by the electric intenseness of the iron-converting process. James Nasmyth, as reported by our faithful correspondent in Staffordshire, continues excited as ever about the new iron—melted without fuel, cooled without scoria, scintillating like silver, stronger than ever, cheaper than ever—about as like ordinary iron as the moon is like green cheese. A windfall to many, in the new process some struggling firms continue to read their ruin.

" Well, it is premature, we presume, to criticise too narrowly the particulars of the new process. We shall e'en sail with the current. We foresee, in the prospective applications of the new manufacture, a crop of monstrous *chef d'œuvres* :—railway bars 100 yards long, 100 lbs. to the yard ; bridge beams for large spans, such as shall astonish Government inspectors, and defy criticism ; steam engines cast in one piece, to the grief of the pashas who abound in our land, killing them, it may be, with perturbation, as did the French the Pasha of Gallipoli. There is little need, however, to cast about for curiosities ; the whole thing is a breather. By a single process, requiring no manipulation or particular skill, and with only one workman, from three to five tons of crude iron pass into the condition of several piles of malleable iron in from thirty to thirty-five minutes, with the expenditure of about one-third of the blast now used in a finery furnace, with an equal charge of iron, and with the consumption of no other fuel than is supplied by the crude iron itself. It is estimated that the economy in cost of production, weight for weight, relatively to the prevalent practice of conversion, will be about £2 per ton, which, for an annual produce of one and a-half millions of tons, will save three millions sterling per annum."

A Seven Day Journal

British Association's Sheffield Meeting

THE 118th annual meeting of the British Association for the Advancement of Science opened at Sheffield on Wednesday evening last. It is the third meeting of its kind to be held in Sheffield, the former occasions being in 1910 and 1879. The president of the Association this year is Sir Raymond Priestley, who, in his address on Wednesday, dealt with "Twentieth Century Man Against Antarctica." Extracts from the address are printed on page 296 of this issue. The various sectional meetings began on Thursday morning, August 30th. Mr. A. C. Hartley is the president of Section G, Engineering. As usual, the papers being presented at the meetings of Section G cover many aspects of engineering, including automation and nuclear energy. In other sections also there are several papers of particular interest to engineers. Sir George Thomson's address to Section A, entitled "Physics and Technology," is but one example; an abstract of it begins on page 297. Then, in the Chemistry Section, the president, Sir Charles Goodeve, F.R.S., delivered yesterday an address on "Steelmaking since Bessemer." It is, of course, a hundred years ago since Henry Bessemer gave the details of his steelmaking process at the Cheltenham meeting of the British Association. His paper, which was presented on August 11, 1856, was printed in full in THE ENGINEER of August 15, 1856. During the meeting at Sheffield, six films, including one on the Bessemer converter, are to be shown as a "centenary tribute." There are also some exhibitions which have been arranged specially for the meeting. They include one, at the City Library, showing how the science and commerce department of the library provides scientific and technical information for industry, and another, in the Metallurgy Department of the University, on the subject of "Metals at High Temperatures."

Building Research

IN its annual report for 1955, the Building Research Board records an "encouraging awareness" in the building industry of the need to support research from which it derives benefit. The report contains a list of research fellowships and payments for special investigations at the Building Research Station. It is stated that these contributions are small compared with the expenditure of the station, but the Board expresses its hope that the scale of this support will grow. In recent years, the report notes, the Building Research Station has studied the programming of building work both with and without mechanical aids, and many firms are now seeking advice from the station on current contracts. Among the work on which the station has been engaged in the last year, there is mention in the report of a series of tests to compare the fatigue strength of prestressed concrete beams with that of ordinary reinforced concrete. These tests have indicated that the strength of prestressed concrete beams under static loading is not impaired if the beams have been subjected previously to repeated loadings within the "working range." The beams may crack, however, under repeated loadings when the bending tensile stress in the concrete is about half that which would cause cracking under static loading. There is also some reference to an investigation of the stresses in tunnel linings. Last year, measurements were made in a tunnel under the Clyde and in seven fifty-year-old tunnels on London's Underground. Vibrating wire strain gauges were used, which were read at night when there was no traffic. Although the study of the results is not yet complete, the report says that some significant facts have emerged. One of these is that when a tunnel is dug alongside an existing one, the lining of the latter distorts; another is that the stress distribution in the lining of tunnels in London clay remains the same indefinitely. The report adds here that there is little evidence of stiff clay yielding with time; in fact, it says, the research suggests that the clay is much stronger and less compressible than had been thought.

Road Improvement at Portsmouth

LAST Monday work was started on a new road, nearly a mile long and 74ft wide, at Cosham, on the northern outskirts of Portsmouth, to relieve congestion on the Southampton Road (A.27). It will be known as the Wymering Link Road and will provide a more direct route from the present junction of the London-Portsmouth Road (A.3) and the Folkestone - Portsmouth - Southampton Road (A.27) to the junction of the Southampton Road and Western Road (A.27 spur). The Ministry of Transport and Civil Aviation has made a grant of £177,798 towards the cost, which is estimated at £246,520. At present, south coast traffic enters Cosham by a road which is only 40ft wide overall, with a 22ft carriageway. There are several bends in the road, which is built up to a considerable extent, particularly along the northern frontage. No fewer than fourteen side roads lead into it and there is a large volume of local traffic. In 1954, the census of traffic disclosed that nearly 7000 motor vehicles and more than 1000 cyclists used the road daily. The new road is to have twin carriageways, each 24ft wide, a central reserve 6ft wide, two grass verges, each 4ft wide, and two footways, each 6ft wide. A roundabout will be provided at each end of the new road, and the existing road will be improved for a distance of 150 yards beyond the western roundabout. The works include the construction, near the western end of the new road, of a bridge over the railway, 28ft 6in in span and 74ft wide between parapets. Two pedestrian subways will be provided at the roundabout at the eastern end of the road, and there will be a third one a little to the west. This will be for the safety of children living on the south side, who will have to cross the road to attend school.

Rural Industries

THE report of the Rural Industries Bureau, for the year ended March 31st last, has just been published under the apt title of "Hand and Machine in the Country." The report is an interesting document surveying the many ways in which the Bureau continues to provide technical advice and assistance to country workshops whose activities include engineering, woodworking, clayworking, saddlery, thatching, and wrought ironwork, to mention but a few! The report emphasises that the rural engineer's workshop continues to be the local centre for serving the mechanical needs of the community, both industrial and domestic, engineering being involved in one way or another in all kinds of industries. The most important work of the rural engineer, however, is to provide a maintenance and repair service to agriculture, a task, of course, which places an increasing reliance on the satisfactory working of a large amount of machinery. The report notes that a serious problem during the past year has been the shortage of small section steel. This, it is stated, has had the effect of holding up work on repairs and manufacture, and at least two workshops had to be closed down as a result. The Bureau has made representations in many quarters with a view to rectifying the situation. The report also stresses that many rural engineers are now fully alive to the need to be efficient and up to date if they are to continue in business. This is revealed by the nature of the technical information which has been sought from the Bureau concerning recently introduced equipment and materials. The demand for instructional courses continues to increase and has, in fact, the report notes, put heavy pressure on the staff of the Bureau. One project which has engaged the close attention of the Bureau's experimental workshop during the year has been the development of a mechanical cutter for harvesting Norfolk reed.

Reactor Conference at Harwell

THE United Kingdom Atomic Energy Authority has announced that it will hold a conference at Harwell on November 30th next, at which the programme of research on advanced kinds of nuclear power reactor systems will be explained to representatives of British industry. The salient points of the particular systems which have been chosen for investigation will also be described. It is stated that accommodation will be available for about 200 representatives from industry. The Authority intends that, following this conference, British firms wishing to do so may be kept informed of the general progress of work on these reactor systems. The information will be supplied at an annual conference on each system. Application for admission to this scheme should be made to the Industrial Collaboration Office at Harwell, where further details may be obtained.

Mr. Oliver Thornycroft, C.B.

IT is with regret that we record the death of Mr. Oliver Thornycroft, which occurred on August 24th, at his home in London, after a long illness. Oliver Thornycroft, who was the son of Sir Hamo Thornycroft, R.A., and a cousin of Sir John E. Thornycroft, K.B.E., the governing director and chairman of John I. Thornycroft and Co., Ltd., was born on April 19, 1885. After completing his education at Bedales School he went to Clare College, Cambridge, where he took his degree and then began his career as an electrical and mechanical engineer. In the first world war he served as a lieutenant, R.N.V.R., attached to the Royal Naval Air Service, and afterwards joined the firm of Ricardo and Co., Ltd., where he was appointed chief engineer and works manager. He continued in this post until 1939, when he became attached to the Admiralty department engaged in mine and anti-submarine weapon research. Shortly after the war, in 1946, he was appointed Director of Aeronautical and Engineering Research at the Admiralty, where he remained for the next four years, and afterwards carried on in business as a consulting engineer. In 1920 Oliver Thornycroft was awarded the O.B.E. and in 1948 was made a C.B. He was a Fellow of the Royal Aeronautical Society and a member of the Institution of Mechanical Engineers, and contributed many articles on engineering subjects to technical journals.

Further French Locomotive Experiences

By EDWARD H. LIVESAY

(*Continued from page 258, August 24th*)

No. IV—"THE MISTRAL," PARIS/MARSEILLES, ELECTRIC AND STEAM LOCOMOTIVES, AND ST. GERMAIN-DES-FOSSES/LYONS, 2–8–2 MIXED TRAFFIC

"THE MISTRAL," running between Paris and Nice, is one of the fastest trains in Europe—I believe *the* fastest over a comparable distance. It covers the first part of the journey, 197 miles to Dijon, in 152 min, at an average speed of 77 m.p.h., and the following 122 miles to Lyons in 95 min at the same speed. It is a particularly interesting train for an observer inasmuch as it is electrically hauled as far as Lyons, and steam hauled thence to Nice, both kinds of power being of the most advanced description, and one has the opportunity of comparing the performance of two completely different classes of engine—in fact, three, should one go right through to Nice. The comparison, however, should not be taken too far, as the electrically worked section of the track, from Paris to Lyons, has been brought up to the very highest pitch of perfection for fast running, whereas the steam-operated part thence to Marseilles has not yet been given similar attention ; it is good, certainly, but not so good. As to the terminal stretch, from Marseilles to Nice, I cannot dogmatise, as my journey ended at Marseilles, but from the fact that oil-burning American "chain-gang" 2–8–2 freight engines handle "The Mistral" over that division it is obvious that high speed is not a feature of the finale. When the whole route is electrified, as it will be in the not very distant future, the through schedule will no doubt be further improved. For the above reasons I was very willing to adopt Monsieur Chapelon's suggestion that "The Mistral" should be one of the services to be investigated, as far as Marseilles, and that on the return to Paris I could stop off at Lyons and go west over the very severe Auvergnes line to St. Germain-des-Fossés, where fine 2–8–2 engines of the latest type were doing impressive work in a lovely rugged setting. It sounded very attractive, all the more so as Monsieur Tapin, who had taken care of me on a previous trip from Paris through Dijon to Bourg (THE ENGINEER, April 23, 1954), would again act as courier and interpreter until our ultimate return to Paris.

"The Mistral" leaves the Gare de Lyon at 1 p.m., and on this occasion was headed by one of the new 80-ton, eight-wheeled B_0–B_0 engines, one of which took part in the recent high-speed test runs near Bordeaux, when 206 m.p.h. was achieved. The load was considered light, 640 tons, and acceleration was correspondingly rapid, over 80 m.p.h. being reached soon after the routine brake test and the frequent curvature in the Paris suburbs had been disposed of—the track limitation is 87 m.p.h. Riding was very good, somewhat better than on the 1–D–1 type I had ridden before ; there was a mere trace of nosing, curves were entered and left smoothly, while switches and crossings were imperceptible.

It is hardly necessary to give a profile of this route as, for the first 160km to Laroche, the gradients are never such as to give a powerful electric locomotive any concern ; thence to Dijon somewhat heavier demands are made on current over the steadily rising 150km stretch to the peak at Blaisy-Bas, but even there gradients are only 1 in 125 to 1 in 200 at times, and such little inclinations do not seriously affect the generating station or the engines it supplies—they merely call for another full field notch or two on the controller. From Blaisy-Bas into Dijon it is all downgrade and level, more an occasion for returning power by regenerative braking than utilising it. From Dijon to Lyons there is far more level going than anything else, and from Lyons right into Marseilles a condensed profile would be practically a Euclidean straight line between two points. In the whole 218 miles the ruling gradient is 1 in 333, except at Tarascon, where, possibly rising to and leaving a bridge, there are a few yards of 1 in 200. A most unusual profile, certainly, but scarcely worth reproducing ; what a perfect high-speed stretch this will make when the time comes to electrify it !

The first 100km, 62 miles, were covered in 46 min, 81 m.p.h., and 145km in 65 min, 82·4 m.p.h., a typical example of "Mistral" running ; I cannot recall ever experiencing the like before. I found this high speed soothing, only the steady hum of the gears punctuated by the regular "ting" of passing signals breaking the monotony. Nobody was saying anything ; there is so little to say in the cab of an electric locomotive ! There is little to watch either—the controller, of course, its handle moving over notches on a segment, affecting series-parallel and parallel grouping, with a separate handle for varying field workings—an ammeter with an 800 maximum—a voltmeter, normally steady at 1500, seldom altering, only nervously quivering slightly in the vicinity of sub-stations. An observer finds a big dial right in front of the driver attracting his attention ; it tells the driver and anyone interested what notch the controller is on at the moment, and is more easily read than the controller-segment pointer. Of course, the indispensable Flaman is there, too, as it always is on every French locomotive irrespective of class or duty—express, freight, steam, electric, diesel, tank or yard engine, every one has its Flaman recorder, with its press-button acknowledging signals, leaving a tell-tale imprint on the paper strip. There is a wheel-slip indicator and sander too, but watching these dials and their swinging needles, hypnotised by the track ceaselessly sweeping towards the engine and disappearing in a blurr of ballast underneath, is sleep-inducing, or so I find it, particularly in the afternoon, following lunch. No stop was scheduled short of Dijon ; Laroche, at the foot of the climb to Blaisy-Bas, was passed at 2.09, and shortly after, at Florentin, there was a sharp restriction for track work, which is always going on somewhere along this very fine stretch of permanent way, probably unsurpassed anywhere in Europe. Blaisy-Bas, the peak, went by at 3.11, followed by a plunge into the cool, clean darkness of the long tunnel just beyond, in which the colour-light signals stood out vividly green. The track here did not seem quite so good ; repair work was actually going on as we went through ; there was perceptible slight nosing and side-sway. Emerging into the glare of sunlight, the line dropped steeply down at 1 in 125, with plentiful curvature, over many stone viaducts and bridges, through rugged, rocky country into Dijon, where the train came to a stand at 3.29, 3 min early, having covered the 197 miles from Paris in 149 min, averaging 79·3 m.p.h., without exceeding 87 m.p.h. That tells its own story of fast, even

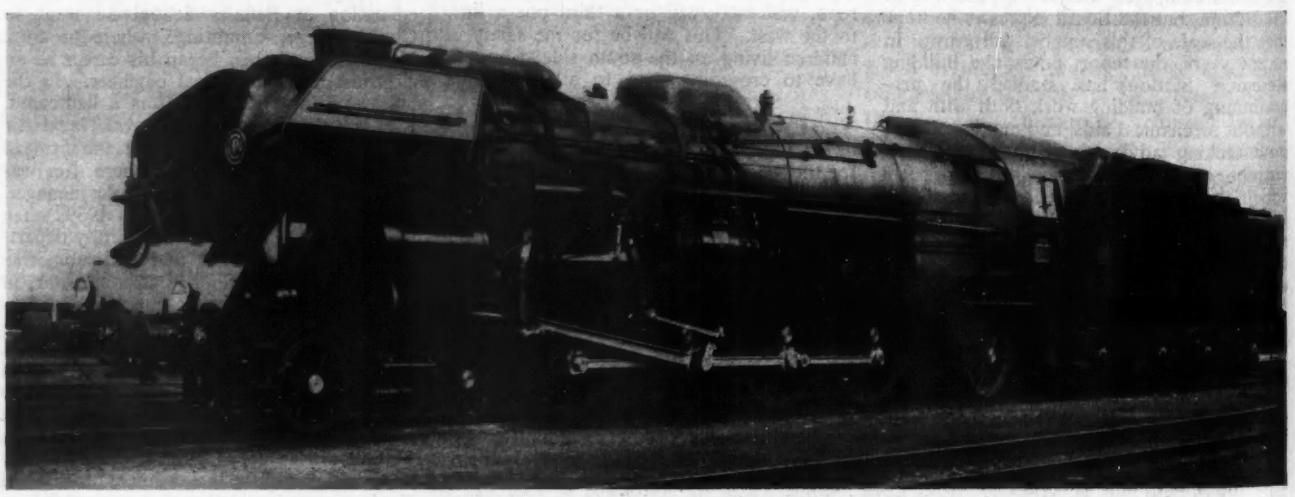


Fig. 1—Four-cylinder compound express locomotive, No. 241.P.1

running, never likely to have been equalled by steam. In view of the 300-odd miles still separating me from Marseilles, to be covered mostly in the cab of a steam locomotive, admittedly more physically trying than an electric, I retired to the train at Dijon to store up energy for the next phase, finding the coach, next to the engine, very quiet and comfortable, but less stable than the B_o-B_e. I was roused by Monsieur Tapin nearing Lyons, and donned overalls, not needed on an electric locomotive, but *de rigueur* on its successor. The train came to a stand at 5.09, 1 min early; 122 miles from Dijon in 94 min, 77·9 m.p.h. A very enjoyable and interesting run, but my heart remained true to my first love, steam. Has an electric locomotive a soul ? No !

Station work is done smartly in France, and stops are generally short ; the electric engine came off, its steam successor backed on, and the " Mistral " was away again in a matter of 8 min, headed by No. 241.P, 4-8-2, four-cylinder compound (Fig. 1), one of the most recent class of express engine on the S.N.C.F., designed by Monsieur Chapelon, and built by Schneider, of Creusot in 1947. The principal details of these impressive machines are :—

Cylinders : (h.p.) two, inside, placed between the first and second coupled axles, are 17·7in by 26in. ; (l.p.) outside, are 26·3in by 27·6in, the ratio between h.p. and l.p. being 1 : 2·6. The piston-valves have a diameter (h.p.) 9·5in and 14·2in (l.p.) with a travel of 5·4in and 7·9in respectively, with inside admission on the former and outside the latter. The two sets of valve-gear are non-independent, as is always the case nowadays with French compounds ; the inside links are worked from the outside valve gear by rocking levers, but the h.p. lead is worked from the tail rods. The h.p. connecting-rods drive the third coupled axle and the l.p. the second. The driving wheels are 6ft 6½in in diameter, the bogie 3ft 3½in, and trailing 4ft 5½in. The boiler has maximum and minimum diameters of 6ft 6½in and 5ft 11½in, and a length of 25ft 10in and carries a pressure of 291 lb. The heating surface is 3647 square feet, of which 978 square feet are superheated ; the grate area is 53 square feet ; the firebox is 6ft 6½in wide by 8ft 1in long, with a large combustion chamber ; stoking is mechanical. The weights are : on the bogie, 30·25 tons, driving wheels 81·4 tons, truck 19·5 tons, total 131 tons. The tender, carrying 9 tons of coal and 7700 gallons of water, weighs 70 tons, making the total weight 201·75 tons. The tractive effort is 44,955 lb. The blast-pipe and chimney are of the Kylchap double type, and an A.C.F.I. feed-water heater is fitted ; electric light, Flaman recorder, adjustable blast-nozzles ; in fact, the equipment lacks nothing that an up-to-date express locomotive should have.

" The Mistral " left Lyons punctually at 5.17 p.m. with a load of 525 tons, a mere bagatelle for such a machine as No. P16, running being made all the easier by the prevailing gradient, mostly level and down, which was to continue right through to Marseilles. Neither Mécanicien Gaddeine nor his mate had anything to worry about—the fireman's name is omitted as I have evidently got it wrong—and Monsieur Tapin remained with me, as interpreter and guide, so I had nothing to worry about either. It is very pleasant to ride on such a super-engine as No. P16 ; one knows it to be the very last word in design and performance, and that there will be nothing whatever to find fault with. A roomy clean cab, thanks to mechanical firing ; every conceivable indicative gauge, showing at all times just what is happening all over the engine ; there is no excuse for boredom on these machines. The fireman was not overworked, nor was he likely to be, stoker-firing, moderate load and easy gradients ensuring that ; in fact, he filled in spare time polishing the cab fittings, a thing I never remember seeing done before while running—or in Britain at any other time either ! The engine naturally was taking things easily, too ; the respective h.p. and l.p. steam chest gauges were generally about 5 and 1½ hpz.—boiler pressure is 291 lb—so the regulator was probably not more than half open. It was of the convenient hanging type, working fore-and-aft, similar to the Gresley " A4 " pattern, and to the invariable pattern in North America. No. P16 could easily have handled 1000 tons over this line, on an equivalent schedule ; it was in perfect shape, riding well, bearing in mind that the track was obviously not quite up to the high standard set north of Lyons ; it will be ultimately, I was told. The handling of this complicated multi-cylinder machine was no more involved than that called for by a two cylinder simple. Both sets of valve gear are worked by one wheel at a fixed ratio, with conjugated mechanism ; there is but one scale, though another, minor one, just above it concerns the variable exhaust nozzles which on this run got little if any consideration, the blast invariably being soft and barely audible. The track limitation south of Lyons being 75 m.p.h., nothing spectacular in the way of speed could be looked for ; the engine was almost drifting.

The first stop was at Valence, 6.25, 2 min early ; 66 miles in 68 min, and a restart at 6.30 on schedule. The next was at Avignon, 7.45, again 2 min ahead of time ; 78 miles in 80 min. Away again at 7.50, there would be no further halt short of Marseilles ; darkness was falling, but with the cab amply lit electrically, every gauge was almost as easily readable as in daylight, which is as it should be. This is 1956 ; a feebly-flickering oil lamp snuggling up against the water gauge as the sole source of illumination in a locomotive cab is an anachronistic absurdity, recognised as such in France.

The line continued its unvarying, gentle fall to the south, a downward trend that had begun some 200 miles back and continued to a little beyond Arles, where there came an easy rise of 15 miles, mostly at 1 in 333, to Mirames, followed by reverse declination of the same degree to Calissane. Then, after a stretch of level another little rise at 1 in 333 beginning at Rognare, led up to the 3-mile Pas des Lanciers tunnel, these being the only adverse gradients of the slightest importance over the entire 354 miles between Blaisy-Bas and Marseilles. A very carefully laid out route indeed ; when the whole of it is brought up to concert pitch it should hold its place indefinitely as one of the best high-speed venues in Europe.

Once clear of the tunnel, it was evident we were nearing our destination ; myriad bright lights twinkled through the warm, velvety blackness, high-lighted by a huge oil refinery, a blaze of floodlit, silvery complication, very lovely seen by night, its industrial crudity veiled by darkness, its engineering beauty magnified by brilliant illumination. " The Mistral " came to a stand in Marseilles station at 9.00 p.m., 3 min early, having covered the 534 miles from Paris in 8 h, at an average of 66·7 m.p.h.

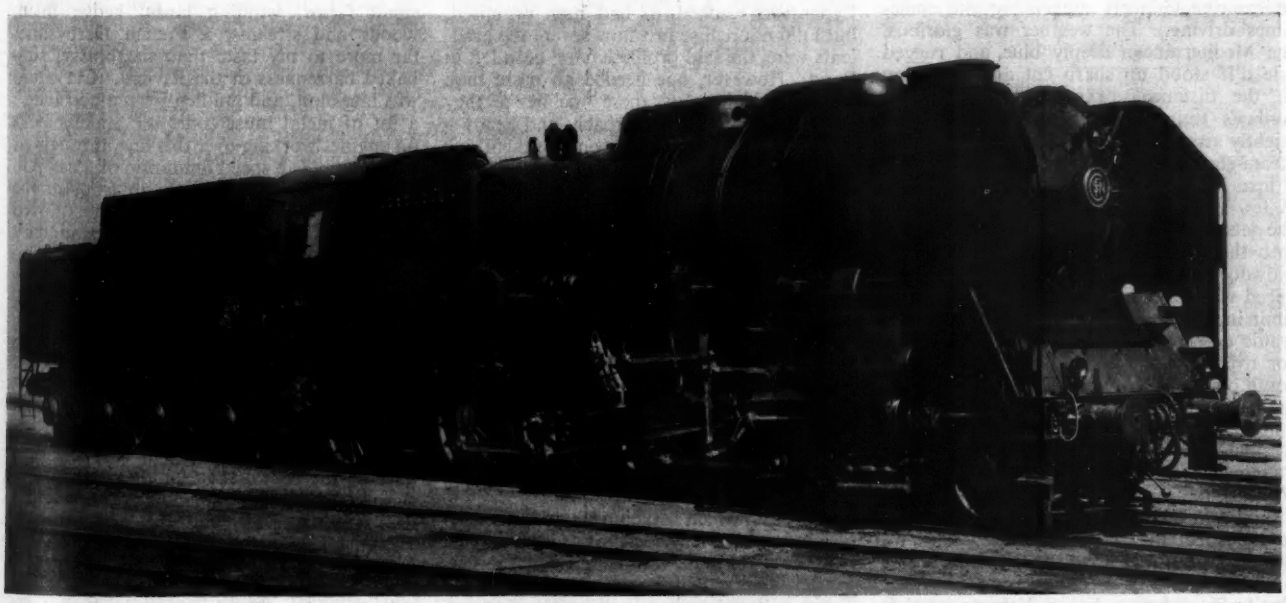


Fig. 2—Four-cylinder compound mixed traffic locomotive 2-8-2

The next day—"*J'y suis, J'y reste!*" It was given over to an interesting tour of the shed and shops, both very well equipped, where steam and diesel motive power are cared for, followed by a brief post-lunch visit to the water-front via the Canebière, Marseilles' chief boulevard, in a blaze of golden sunshine and 85 deg. heat, to me rather trying, suffering as I was from a violent cold, no doubt caught a few days before on the Havre run, during which the fireman left the scoop down too long and soaked me to the waist. A fascinating city, Marseilles, the gateway to French Africa and the East, very, very old. I noted a plaque reading "Here, about the year 600 B.C., landed Greek sailors coming from Phocaea . . . they founded Massalia, from which civilization spread to the West." Greek traders pushed north up the valley of the Rhône and Saône to Lyons, through which P16 had rushed south the day before; the Crusaders came down by the same route and embarked at Marseilles. History has certainly been written here. A city of contrast, a kaleidoscope of luxury and poverty, solidity and slums—of Italians, Algerians, Arabs and Jews, but seldom French—of distinctive smells, such as seaweed, roast chestnuts, cheese and olive oil—of sun-baked, shuttered houses, but lacking trees and greenery, which would take some getting used to by a northerner.

Marseilles, through its deputies, S.N.C.F. personnel of all ranks and ratings, was kind to me, and I liked it. We—Monsieur Tapin and I—stayed at the hostel, dining at a nearby outdoor café much favoured by enginemen, where the food was good, the drinks plentiful, and one could pick figs for dessert from a tree overhead without getting up. The good lady who ran the café, full of sympathy for the ailing stranger within her gates, dosed me and my cold with some weird mixture that she guaranteed would either kill or cure, and which I took on trust, hoping for the best, and was not disappointed; the cold disappeared—when I got back to England a couple of weeks later.

We returned north the next day with train No. 52, a "Rapide," from Monte Carlo and Nice, consisting of sixteen coaches, 780 tons, which left Marseilles on schedule at 11.44 a.m., headed by P9, 4–8–2, of the same class as yesterday's, in charge of Mécanicien Beaume and Chauffeur Besson, with Chief Mécanicien Gaubert supervising and sometimes driving. The weather was glorious, the Mediterranean deeply blue, and rugged Isle d'If stood up sharp cut and menacing in the distance. The greater weight of to-day's train, together with the constant slightly rising gradient, had their effect, the steam-chest gauges showing 16½ hpz. and 4 hpz. instead of yesterday's trifling figures. A few scoops of coal were fed at intervals, the jets not getting the fuel snugly enough into the back corners of the box, and the blowdown was opened every 50km. The speed was religiously held within the 120km limit in effect to Lyons; there seemed less traffic down here than I had anticipated, as for over an hour not a single train passed south on the other metals. A stop was made at Avignon, 12.58, rather longer than usual, 13 min, the train having arrived well ahead of time, and water being taken; 75 miles in 74 min. We left on schedule at 1.11, reaching Valence, the next stop, at 2.35, 2 min early—77 miles in 84 min, 55 m.p.h. I find a note to the effect that no train passed until we were beyond Valence, though this seems unlikely—possibly I missed one or two! But traffic did seem light. Valence was left at 2.44 O.T. and as no further notes were made of happenings *en route* to Lyons, presumably nothing of importance occurred, or perhaps I was still under the weather, dopey and unobservant; we came to a stand in Lyons-Parrache station at 4 p.m., again 2 min ahead of time—66 miles in 76 min, 52 m.p.h. Train No. 52 apparently took things progressively more easily the farther north it went. However, it had been a very pleasant run on a splendid engine hauling a heavy train, and I dismounted from P9 with regret, to dine, and afterwards, tired, sleepy and with aching bones—not due to P9, but my cold—to travel in the train to St. Germain-des-Fossés, an Auvergnes town in the neighbourhood of Vichy, from which a fine 2–8–2 would take us over tremendous gradients back to Lyons the next day. We were scheduled very late into St. Germain-des-Fossés, and the quiet little place seemed to have turned in for the night, but comfortable accommodation was found by Monsieur Tapin at a hostelry near the station, where it appeared we were the only guests and were welcome.

Next morning, up early, in darkness and fog, giving promise of a fine day later, atmospheric conditions were a complete contrast to those experienced at Marseilles the day before, but fields silvered with hoar-frost and the sun beginning to show through a rising mist were preferable to scorched earth and shuttered buildings shimmering in 85 deg. heat. At the station, the engine rostered for the trip was No. 141.P.47 (Fig. 2), one of the latest 2–8–2 mixed-traffic four-cylinder compounds of Monsieur Chapelon's design, heading a train weighing over 500 tons. The profile shows that very heavy work would have to be done before Lyons was reached, as had been promised, but I did not realise just how severe the gradients were, the said profile having been left in Paris. However, one needed no more than ocular evidence of these inclines; they could be seen on the approach, and heard—from the exhaust—when ascending them.

The principal dimensions of No. 141.P.47 are as follows:—

Driving wheels	5ft 4½in
Cylinders:	
Two l.p., outside	16½in × 28in
Two l.p., inside	25½in × 28in
Heating surface:	
Firebox, square feet	156
Tubes and flues, square feet	2010
Superheater, square feet	939
Total, square feet	3105
Length of tubes	19ft 9in
Grate area, square feet	46·24
Coal, tons	9
Water, gallons	7700
Steam pressure, pounds per sq. in.	291
Weight:	
On drivers, tons	76
Leading truck, tons	17·4
Trailing truck, tons	18·8
Total, tons	114·2

Walschaerts valve gear, non-independent; piston valves; A.C.F.I. feed heater, one L.s. injector; mechanical stoker; Kylchap double chimney and blast pipe.

The train, which had come from Clermont-Ferrand and Vichy, left St. Germain-des-Fossés at 7.11 a.m., with enginemen Vincent, Martel, chief engineman Dumas, Monsieur Tapin and the writer in the cab, rather a "full house," but there was no inconvenience, as mechanical stoking leaves the fireman more or less static, and nobody was in his way. Fairly severe climbing, 1 in 120, began almost at once, but it was nothing to what would come later. Nevertheless, the combination of gradient and heavy load, 500 tons, called for full regulator, 30 per cent v.t., which resulted in h.p. and l.p. gauge readings of 19 and 4½ hpz. respectively, the highest figure I remembered noting previously in l.p. cylinders. The feed water heater and pump were not put on at first, pending a rise in the former's temperature; the engine was evidently in perfect shape, with riding to correspond; there was not a knock or leak anywhere about the motion of this complicated four-cylinder machine, everything working like a sewing machine—I seem to remember using this simile before. The general outlook was in cheerful harmony, too—the mist clearing, licked up by the sun, frost glistening on the grass, green hedges and trees a welcome sight after yesterday's heat and burnt-up pastures in the South of France.

It should be explained that the profile (Fig. 3) figures are *average* merely; that is, the ruling ones over each section, from which it will be evident that most of the stretch to Lapalisse was at steep inclination, and that this applies to the profile as a whole. Arfeuilles, the first stop, brought half a kilometre of breathing space between two steep pitches, 1 in 134 on the approach and 1 in 114 leaving, the latter merging into a continually ascending gradient nearly to the peak in the tunnel at St. Martin. Then came a long descent through lovely country with scarcely a break into Roanne, a prospect of small farms, winding lanes, hedge lined, woods and streams, a French Derbyshire, far more to my taste than the brassy, sun-baked barrenness of the Riviera. Curvature was incessant, and gradients steep and long; a lot of metal must come off brake blocks on engines working over this line, throughout which there is a speed limitation of 65 m.p.h. The Flaman recorder, right in front of the driver on this engine, has two hands, red and white, the former remaining stationary at the allowed maximum; when the two hands come together—brake! I rather wondered braking over this route was not automatic; it would only have been in keeping with the thoroughness noticed so often on the S.N.C.F.*

Roanne, the next stop, is the junction of two routes to Lyons; we took the heavier and more direct, via Lozanne, crossing the Loire, and at Le Coteau began the heaviest part of the route, the 20-mile climb to the summit beyond Amplepuis; Le Coteau lies at 921ft a.s.l., and the peak at over 1500ft. The day had become perfect, the Loire "steaming" under the warm sun, every lovely outline softened by the slight thinning mist still lying in the valley at the

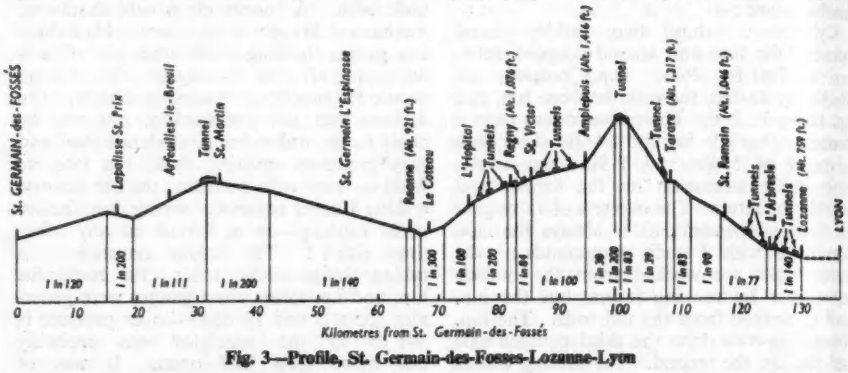


Fig. 3—Profile, St. Germain-des-Fosses-Lozanne-Lyon

* Or counter-pressure—and I am not sure that it wasn't.—E.H.L.

foot of the incline, that could be seen winding away ahead up the mountain side, becoming progressively steeper through l'Hopital to Regny, where the "real thing" began, 1 in 100. It was steeper still to St. Victor, 1 in 84, after which it eased slightly to Amplepuis, the station thoughtfully built on the level to usher in the climatic 3 miles of 1 in 38 to the summit. One in 38 equals the Lickey incline, but this Auvergnes climb is a mile longer. A "pusher" came on at Amplepuis —only used when the load exceeds 300 tons, a proviso that I should not think applies to the Lickey—the train weight being over 500 tons. On this exceptionally severe ascent, even with pusher assistance, I noted the steam pressure as 19/20 hpz., or near 290 lb, with the h.p. steam chest gauge showing practically the same figure, and the l.p. 5, the highest I ever logged at any time in France; the cut-off, common to both sets, was 60 per cent. On the steepest part of the incline the speed was approximately 20 m.p.h., really very creditable, even with the vigorous help of the pusher at the rear, from which could be seen a plume of steam shooting straight up into the blue, a replica of No. P47's. Climbing higher and higher, through very pretty country, on a fine engine doing such heavy work made the experience thoroughly enjoyable. The profile shows the summit to be right in the tunnel, which was entered with both engines obviously digging their toes in, but while still *in medias res* the regulator was shut, much of the tumult and the shouting ceased, so evidently the pusher had dropped off, and the train emerged into bright sunshine running quite fast, with brakes on. Immediately, P47 blew off, and an injector was put on to check this exuberance, in lieu of the A.C.F.I. feed heater, not available with a shut regulator. The speed increased to 45 m.p.h.; one could see the track dropping away from under the engine at an even sharper inclination than that just climbed, 1 in 39 for 4 miles, the steepest gradient of that length I have experienced anywhere—with the exception of the rack railway up the Rigi! Even the C.P.R. in the mountains now has nothing more severe than 1 in 44. The brakes, firmly but not obtrusively holding, finally went on hard for the stop at Tarare, the station another rest-and-be-thankful before a further tremendous fall of 10 miles to L'Arbresle, followed by 3 miles at only slightly less inclination into Lozanne. At Tarare we were 4 min late, but no doubt they would be recovered before Lyons—and were.

Audible signalling into the cab was, of course, used on this route as everywhere else in France, but with a slight difference, the whistle only sounding when a signal was "on." I had just enquired about this, it having struck me that nothing had been heard all the morning, when it sounded on the approach to Lozanne; we were out of the hills now, speeding up and recovering the lost minutes. Monsieur Tapin explained that when a train gets 15 min or more late, it is often difficult to make them up, though every effort is made to do so; a bonus for time-recovery is paid to the mecanicien, which is where the value of the Flaman recorder shows up, as without it the plan would not be feasible. A time recovery bonus certainly does not lead to the disregard of restrictions, which are meticulously adhered to; again, the Flaman prevents this, with its permanent black-and-white record. How different all this is to the British attitude; in my experience very seldom is any real effort made to recover lost time. In France, during thousands of miles' running, only once was a train on which I was travelling late into its terminus, Paris, and that was only a local "pull-and-push" delayed a minute or two by platform occupation. In Britain, on the other hand, it has only been on rare occasions that I have reached my destination punctually. The worst instance of indifference I recall was quite recent, when, on a long footplate trip with a well-known train, it arrived in London 42 min late, partly the result of defective motive-power, but I cannot recall that the enginemen were very concerned. Granted it was not their fault, but I can picture a French crew under similar circumstances! *Sacré nom d'un chien*!

Following the stop at Lozanne, only a mile or two remained to Lyons, where we arrived, at 9.52, not merely on time but 2 min ahead of it. I congratulated the crew, through Monsieur Tapin, on their admirable performance over such a very heavy route—but, of course, they really did have an engine to work with!

Train No. 54, "Rapide" electric, was taken from Lyons to Paris, the engine being No. 9132, 1-D-1, but I did not travel in the cab at first as a movie picture was being taken *en route* to Chalons, and I slept peacefully in the train most of the way to Dijon. There I went to the engine, intrigued by a twenty-car, 1000-ton train, an experience that would be well worth recording. We left at 4.23, 6 min late, to immediately attack the heavy 20-mile climb to Blaisy-Bas, much of it 1 in 125, taken at high speed. My log says: "Feeling of security—audible signalling—perfect track —smooth running engine—complete equipment." That is the impression the whole run had made upon me. The first stop, at Laroche, was at 5.5 5O.T., 93 miles in 92 min; away, the speed quickly rose to over 80 m.p.h. at which there was a little quick nosing, nothing of importance; this was one of the older 1-D-1 engines, now superseded by C_0-C_0 and B_0-B_0 classes, with which the recent 206 m.p.h. speeds were achieved. The sinking sun, now nearing the horizon and shining right into my eyes, together with the smooth humming flight of the engine, made it difficult for me to keep awake; the past strenuous three days were having their effect. However, I noticed sundry things, such as the "Hallade" marker cones, much in evidence on this stretch, and the fine, quiet running led to enquiries as to whether rubber sole plates, placed between rail and sleeper, which have been quite extensively tried on the S.N.C.F., were in position here. I gathered these are used chiefly with concrete sleepers, in conjunction with which they have been quite successful; wooden sleepers are standard on this Dijon-Paris line.

The picture (Fig. 4), taken from the cab at 80 m.p.h. between Laroche and Sens, gives a good general impression of this stretch of track, which as regards layout, careful maintenance and completeness of equipment must approach perfection. It includes several things that have come into this account more than once, such as the colour-light, automatic "distant" signals, with the attendant ramp between the metals activating the audible warning apparatus in the cab; a substation is seen on the left, and the "Hallade" markers, from which lateral track movement can be gauged, show clearly. The overhead equipment, so light and unobtrusive, is far less angular and graceless than similar gear is apt to be in Britain, where crude simplicity is apparently the overriding factor, and appearance goes for little. We seem to lack the more delicate Gallic touch—look at the new concrete lamp standards, for instance—one cannot imagine *them* in Paris! Consider, too, the deplorable crest decorating, God save the mark, the sides of British locomotives—who or what was responsible for that aberration? Verily, the punishment to fit that crime should be something lingering, with boiling oil in it. The sooner this perversion is discarded in favour of a crest that does not offend every canon of art and symbolism the better. But I digress; it was mentioned to stress the impossibility of conceiving the S.N.C.F. ever perpretrating such a deformity.

Sens was the next and last stop short of Paris, at 6.16 O.T., after which there was only one further entry in the log, the arrival in the Gare du Lyon at 7.25, 2 min early. The 195 miles from Dijon, with two stops, had been covered in 182 min, at an average speed of 64·3 m.p.h. Monsieur Segaud, who had arranged all the runs, greeted us, anxious to hear what I thought of the excursion, an unexpected courtesy typical of him, and all my association with the S.N.C.F. This account makes my impressions plain enough.

Fig. 4—Taken from cab at 80km per hour between Laroche and Sens

(*To be continued*)

NEW EARTHMOVING EQUIPMENT.—The "Track-Marshall" 48 b.h.p. diesel crawler tractor, manufactured by Marshall Sons and Co., Ltd., of Gainsborough, can now be supplied with either a hydraulic angledozer or hydraulic bulldozer. Both the equipments have been designed specifically for the "Track-Marshall" by W. E. Bray, of Feltham, Middlesex. The "Track-Marshall" is powered by a Perkins L4 engine, rated at 48 b.h.p. at 1600 r.p.m. A six-speed gearbox gives the tractor speeds of from 1·31 m.p.h. to 5·15 m.p.h.: there are two reverse gears. The steering is by a controlled differential system, operated by hand levers. The drawbar pull obtainable in first gear, with a bare tractor, is in excess of 12,000 lb. The design of the hydraulic system is common to both the equipments, and consists of a live pump, driven from the front of the crankshaft, a reservoir tank containing the control valve assembly, which is mounted beside the driver, and two double-acting hydraulic rams which lift the blade through quadrant arms. The angledozer blade is mounted on a separate "A" frame which allows the blade to be angled to both the right and the left; the blade can also be cambered in both directions. The bulldozer blade and frame are an integral unit. Renewable and reversible cutting edges are fitted to both the equipments, and replaceable corner shoes are fitted to the angledozer. The design of both units allows the fitting of such items as a cable control unit or logging winch, without interfering with the dozing equipment.

Twentieth-Century Man Against Antarctica

By SIR RAYMOND PRIESTLEY, M.C.

In his Presidential Address to the British Association, last Wednesday, Sir Raymond Priestley reviewed the history of Antarctic exploration. We print below the concluding section of his address, which reviews, with some special references to the Antarctic, the work that will be carried out in the International Geophysical Year, 1957–8.

TWICE in the past, in 1882–3 and 1932–3, the scientists of the civilised world have planned an International Polar Year. To-day they plan again, but, as is fitting, on a vastly larger scale the International Geophysical Year for 1957–8. Although it is intended to cover the whole earth with chains of stations from pole to pole, the systematic exploration of the physical phenomena in and over Antarctica is a most striking component of the plan. A long-range practical objective has been described as a better understanding of climatic variation and the study of the nature of long-period climatic change. We are apt to forget how much the present pattern of our civilisation depends upon the latent heat of the ice. If the present ice sheets of the world melted in a hurry, sea level would rise somewhere in the region of a hundred feet. This would, among other painful things, bring about the greatest slum clearance the world has ever known. The present long-term tendency to glacier retreat is, however, accompanied by a rise in sea level of only 4in a century. The rise in the temperature of ocean water that accompanies this climatic change has important repercussions on the fishing industry, upon which the welfare and livelihood of tens of thousands of European families depend. Another question still a matter of controversy is whether continents move, and, if so, at what rate. A fuller knowledge of the ionosphere will help in improving wireless communications which are now essential to our mode of life. Upper atmospheric studies are important in the future development of high-flying aircraft.

The immediate observations that will be made in 1957–8, chosen because it is a year of nearly sunspot maximum, are, however, concerned with the exact recording of physical phenomena which will appear to the layman as the purest of pure science. Yet Sir Edward Appleton has lately reminded us that history has taught us to regard pure science as the capital of scientific knowledge, capital that has yielded astonishing dividends from time to time.

The world is entering on its latest experiment in a big way. A mere enumeration of the subjects of study is evidence enough of the comprehensive nature of the programme. Meteorology, the study of aurora and airglow, geomagnetism, ionospherics, ozone, cosmic rays, glaciology, solar activity, variation in longitude and latitude, seismology and oceanography, are all embraced. I can even visualise a little geology being done on the side, though most of the people concerned may never handle Antarctic rock. The total cost of the plan has been assessed at £100,000,000. No less than forty-five nations have pledged themselves to play their part. In and around Antarctica there will be over forty stations, of which three will be, respectively, at the geographic pole, the geomagnetic pole, and the Pole of Inaccessibility.*

* The term was first used by Vilhjalmur Stefansson to indicate the point in the Arctic Ocean which was theoretically most difficult of access under the sledging conditions prevailing in his time. As applied to the Antarctic Continent, it must presumably mean the spot on the inland ice most remote from an attainable base.

These last will be supplied and maintained entirely by air.

The most spectacular element in the plan is the examination of the upper regions of the atmosphere. Man reaches further towards space than he has ever done before. It is planned to employ man-made satellites, despatched by means of three-stage rockets, to a height of 200 miles, there to girdle the earth in an elliptical path which varies between 200 and 800 miles, in ninety minutes dead. The satellite is expected to stay up days or weeks, before it falls and is consumed, as are millions of the meteorites that enter the atmosphere every day. Large rockets will reach out—their tracks like slender fingers—to several hundred miles above the earth carrying heavy loads of recording apparatus. Rockoons, smaller rockets launched from balloons 27 miles up, can carry a lesser load to a height of over 60 miles. Small rockets may be dispatched from aircraft in flight.

Balloons will be launched trailing a variety of instruments, tracked throughout their course by observers, eventually parachuting to earth. Automation, a cause of anxiety and unrest here at home, can be seen with more detachment as an essential element of the I.G.Y. plan. Perhaps it is at its most dramatic in the so-called "Grasshopper," a small recording device weighing 200 lb, which can be dropped from an aeroplane at any desired spot. As described to me, it automatically opens, rights itself on its six legs in true insect fashion, and goes into action. "It gathers weather information at predetermined intervals, transcribes it automatically into International Morse Code, and transmits it by radio at seventeen words a minute." It works for sixty days and records and transmits surface wind speed and direction, temperature, barometric pressure and humidity. To one who has toiled to and fro between hut and screen, this sounds to be a very desirable development indeed—a distinct advance towards *Utopia Antarctica* and not a matter for grousing at all, even if the substitute job is handyman or cook.

Already I.G.Y. has begun to work its transformation of the Antarctic scene. Direct American flights from New Zealand to Antarctica have taken place. The Russians are in regular wireless touch with Moscow and plan a supply route direct from the U.S.S.R. by air. The continent is becoming studded with little towns. Icebreakers plough the Antarctic seas with internal temperature kept at 75 deg. Fah.: a fact that reminds me vividly of what I reckoned to be one of the hardships of American life. In this great effort Britain plans to play a worthy part. One major expedition, sponsored by the Royal Society, is already established near 76 deg. S. in the Weddell Sea. The Falkland Island Dependencies Survey bases are being reinforced to help.

Dr. Fuchs's transantarctic expedition is a horse of a rather different colour, though it will, as a side issue, contribute to the plan. He intends to cross the Antarctic Continent from west to east. It has been said in criticism that the British have been so obsessed with the story of Shackleton and Scott that they cling unduly to outmoded ways. We have, it is true, suffered from too strict adherence to tradition in the past. There is an element of gambling in the present transantarctic plan. But Fuchs intends to take seismic soundings of the ice depth together with a continuous gravity traverse as he makes his way across. In addition to tractors and aircraft, he will have auxiliary dog transport to examine rock exposures he may meet along the unknown country he has to traverse. Of all the modern equipment the small electronic device weighing less than 1 lb, by which he can home on his moving column from distances up to 25 miles, attracts me most. If he is fortunate he may come back with results that will, of their kind, be as valuable as anything his more sedentary competitors can possibly produce. And there is an element of adventure that, for any normal citizen, will definitely add to the fascination this particular venture exerts. Good luck to him. May he and his men so conduct themselves that, if they do fall short of complete success, they will, like Shackleton of "Endurance" fame, come out of the trial with reputation not diminished but enhanced.

The Future

When I left England with Shackleton in 1907, I travelled to Australia in six weeks by sea at a cost of £19 from a London where the four-wheeler horse cab was still commonplace; where wireless was in its infancy and a criminal could still hope to outpace the law by ocean travel. I lived in a world which was, by and large, convinced that mankind was unique and life confined to Earth. The expedition left New Zealand on New Year's Day, 1908, and for all its countrymen knew about what was happening in the next twelve months we might have taken off into space. The first tentative flights were being made in machines heavier than air.

To-day I return to England for the British Association meeting from Australia in the inside of three days at a cost of £300, to find Dr. Fuchs in constant touch with his colleagues in Antarctica, in a world in which a Harvard professor of astronomy has recently asserted in a London Sunday newspaper that life exists on a million worlds. His country proposes to launch an earth satellite as part of its I.G.Y. programme. American airmen are flying hundreds of tons of stores from New Zealand to Antarctica as an ordinary Service transport operation.

Who can predict what may happen in a similar tale of years in the future? Antarctica may be colonised: man may have landed on the moon. On the other hand, it is as likely that, if man's passions get out of hand—and control of emotions is not a notable twentieth-century trait—the survivors of mankind may be plunged in a Dark Age such as has succeeded civilisations of the past at least nine times in the chequered history of mankind. Man is indeed at a crossroads to-day. We of the British Association may well ask ourselves what we can do to help the world to make the choice that will ensure the survival and further progress of humanity perhaps to the point when man is no longer earthbound.

So far as the future of Antarctica is concerned, we still have too little to go upon for speculation to cut much ice. Now that atomic energy is available and atomic power is immediately ahead, the mere strategic threat of a monopoly of Antarctica by any one Power should by itself suffice to keep the

interest of the nations alive. Great and valuable mineral deposits there must be in any continent of this size and kind, though nothing of significance has so far been found. Prospecting on the continental scale, let alone exploitation, will be so costly that, apart from a stroke of luck, it will require finance and organisation at least on the national scale to ensure success. In 1951 the £200 million Kitimat project was started in a completely undeveloped area in British Columbia and is just about to pay off. But this is based on cheap local power and will be used to process aluminium ore brought 4500 miles from Jamaica. In Antarctica something on this scale would be the least that would be required should large and valuable ore bodies be found. Airborne magnetometers and stereoscopic camera mapping are already in use in Antarctic surveying. Future exploitation lies with the co-ordinated use of airborne surveyors carrying out wide sweeps and of helicopter-borne ground parties equipped for high-speed core drilling and rock sampling. In Canada five geologists with two helicopters have prospected in one season some 67,000 square miles. Attention must needs be concentrated, as at present, on the relatively few exposed rock surfaces where mining could be carried out without difficulties arising from ice movements. Once the ore is located the whole enterprise could gradually go underground. Tunnel or adit entry might be followed by the construction of underground engine-rooms, hoisting gear and mineral dressing plants. Floating power stations that could be withdrawn for maintenance during the "closed" season might be a useful expedient in the initial stages, but land-based stations would be essential to any permanent settlement. Once a footing had been obtained anything might happen.

It has been suggested, for example, that the Antarctic might have a future use as a vermin-free store for the world's periodical food surpluses where these might be preserved against the needs of future generations, since widespread crop failures might otherwise spell disaster to a world whose population seems destined to increase. Again, one of the main claims for atomic power is that it can be maintained for long periods in remote places with a minimum of attention and thus might be used for the development of the desert areas of the world, uninhabited to-day because they are too cold, too hot or too dry. If atomic-powered icebreakers can be built, why not atomic-powered settlements on the Antarctic mainland ? The harnessing of the Antarctic gales is another possible source of power. But everything will depend upon the discovery of a worthwhile economic objective, and this is not, at the moment, in sight. The chances are that, for the remainder of this century, Antarctica will remain the scene of investigations in pure rather than applied science. But man may yet find a way to overcome the latent heat of ice and add a seventh habitable continent to the six he already has in thrall.

Physics and Technology

By SIR GEORGE THOMSON, F.R.S.

In his presidential address to Section A, at the meeting of the British Association in Sheffield which began last Wednesday, Sir George Thomson first reviewed the inter-action between physics and technology and attempted to define the difference between the physicist and the engineer. He then went on to refer to a number of products, in the design and production of which physicists and engineers had to combine. He talked, too, of nuclear power, electronic computers, transistors and the establishment of an artificial satellite for the earth.

IN early days technology owed little to science. The earliest discoveries—for example, the smelting of metals—were made before science existed. Later discoveries were made, for the most part, by humble men, who lacked the education of the age. Practical arts were intellectually despised—even the painter and the sculptor did not rank very high in social esteem—and discoveries were made more or less by accident, and often kept as trade secrets. To some extent the art of navigation was an exception, which early depended on primitive astronomy, and came in the Middle Ages, and perhaps earlier, to depend on the astronomical science of the day. Compare, for example, Chaucer's treatise on the astrolabe. Navigation, too, had its influence on science. It is, perhaps, not an accident that the first real scientific treatise published in England, and almost the first in the world, was Gilbert's *De Magnete* of the year 1600. Gilbert, the physician of Queen Elizabeth, studied magnetism primarily in relation to navigation. It was terrestrial magnetism, as we should now describe it, in which he was primarily interested, though his study was a model of the scientific method.

But technology is only one source, and perhaps not the most important, of physics, which has also come from the instinct of curiosity that is innate in mankind, the study of odd phenomena ; the reflected face seen in a pool ; the apparent breaking of a stick as it passes through water ; the attraction of rubbed amber for pieces of chaff ; the twitching of frogs' legs in an Italian butcher's shop—it is from such sources as these that physics owes the greater part of its origin. Nevertheless, technology played a part—the study of heat received a great impetus from the invention of the primitive steam engine, so that by a queer paradox the second law of thermodynamics was discovered before the first ; and here we see an early example of the interplay between technology and science, for it is on record that Watt was asked to repair a model of the Newcomen engine in the possession of the Department of Natural Philosophy at Glasgow University when he was an instrument-maker there, and this no doubt helped to direct his ideas towards steam.

But the real influence of physics on technology starts with electricity. From its start electrical engineering has been directly dependent upon scientific discovery. The very first electrical machine, the lightning conductor, derived directly from Benjamin Franklin's experiments, and so it has been throughout. The dynamo came from Faraday, though it took nearly fifty years after his discovery before it reached real commercial importance. Radio comes from Maxwell and Hertz. The cathode-ray oscillograph, that universal tool in modern laboratories and engineering works, is a development of J. J. Thomson's apparatus for measuring e/m, and has itself developed into the television tube of the home. Still more true is this of the new industries based on physics, where the physicist is still in charge.

But if technology owes physics a debt, it has well repaid it, for to the progress of technology, physicists owe the machines, without which progress in physics would be impossible. First and foremost, of course, are the precision machine-tools which are so necessary in every laboratory workshop, but hardly less in importance come the devices which industry has taken in the first instance from physics, greatly improved and handed back to us. For example, the vacuum pump. What a difference there is between the old days, when the unfortunate physicist had to exhaust his apparatus by means of a mercury reservoir, laboriously raised and lowered several times a minute, and present pumps, enormous in power, which make it possible to exhaust to the lowest vacuum large and complicated pieces of apparatus. This advance could hardly have taken place unless vacuum pumps had become an important piece of commercial equipment for making lamps and valves. Other examples are the valves themselves, which are made cheaply and in great variety because of the commercial demand, and the innumerable cheap radio components which enable the research student in physics to spread his ingenuity in devising complex "electronics." The debt is being abundantly repaid.

I should like to turn aside for a moment to consider the position of the physicist in industry. Only shortly before the war there were comparatively few people engaged in industry who called themselves physicists. Now the number is increasing exponentially. Let us consider for a moment what the difference is between the physicist and the engineer. Superficially, one might say that physics is the theory of engineering, and that engineering is applied physics—and this, I think, would have been a satisfactory answer fifty years ago, but now there are people in industry who call themselves physicists and feel that they are different from their engineering colleagues, although they may be engaged on the same work—and, anyhow, for the same purpose. I think the difference lies in the character of the knowledge which they use, and the problems which they tackle. The engineer is a man who, besides knowing the theory underlying the problems he has to tackle as far as it has yet been discovered, has, in addition, a background of experience, acquired sometimes by himself, but more often by other people, which helps him in design. Fundamentally the engineer ranks with the artist, his job is to make a *design*, that is an organic whole, and his theory helps him rather as perspective helped the artists of a now bygone age. Beyond this he depends on knowing similar designs in the past. He does not start completely from first principles ; to do so would be wasteful. He rather modifies last year's designs to suit changed requirements. The physicist, on the other hand, has little of this know-how. He is best at those industrial problems where development is very rapid, and where in consequence little know-how has accumulated. His value to the industrialist lies in that he is prepared to look at things from first principles, and to try a variety of quite different modes of attack. His business is to get the thing to work somehow, but the product he makes is apt to be scrappy, lacking in unity, very likely to go wrong. It is for the engineer to tidy it up and make something that can be worked by a housewife.

Let me now consider a few of the particular

instances in which physics is being applied. Remember that these are only instances from an enormous field. I will begin with the one that is, perhaps, most in men's minds—the applications of nuclear energy. I shall not discuss their applications to the technology of war ; it is a fascinating subject, but a horrible one, and one may hope, without foolish optimism, that these applications will remain purely experimental. But on the peaceful side they are going to be real enough. First in importance comes the application to the production of energy.

Nuclear Power Production

It is hoped that before this year is out electricity will be fed into the grid from the first of the nuclear generators at Calder Hall. For a year a much smaller generator has been working in Russia, and American submarines have been powered by nuclear energy. Nominally, perhaps, this last is an application to war, but the engines which drive the "Nautilus" could equally well drive any other kind of ship, if it were worth while commercially.

You will remember, of course, that nuclear energy, at least up to the present, is applied in the form of heat ; the chain reaction by which atoms of uranium or plutonium split under the action of neutrons, and themselves yield more neutrons, generates enormous amounts of heat. It is in this form that the energy appears. Nobody has yet devised a means of generating electricity from fission directly, though, of course, it is the electrical force of the repulsion of the two halves of the dividing nucleus which provides the energy. It seems a very difficult thing to do, though perhaps not absolutely impossible. Some electrical energy can be produced directly from the fission products, but these only account for a small part of the total energy involved. The reactor then, as the device is called which utilises the chain reaction, is essentially a furnace, and the heat from it must be turned into electricity by some kind of conventional method. In the Calder Hall piles the heat will be removed by carbon dioxide and transferred through heat exchangers to water and steam. The steam then goes into the turbines driving the dynamos, which generate the electricity. I need not, perhaps, go into the details of the very extensive programme for the development of nuclear energy here, which has been set out in the White Paper, but I might just recall that by the year 1975 it is expected that 40 per cent of the, by then, considerably increased generation of electricity in this country will come from nuclear power, and that this will save approximately 40,000,000 tons of coal per annum. There have been few cases in economic history in which a new discovery has come so completely in the nick of time. It seems impossible for us to produce in this country more than about 200 million tons of coal a year. The difficulty is perhaps more a matter of psychology and social conditions than of engineering, but that makes it no easier, and perhaps harder, to overcome. Anyhow, from being a coal-exporting nation we are rapidly becoming a coal-importing one. The dollars that can be spent on this are limited, and it looked as though the country would be strangled by its inability to expand its use of power, the thing above all others which matters in modern industrial economy.

It is sometimes asked what will happen when the uranium runs out. I do not think we need be afraid. It was stated last year at the Geneva Conference that 1,000,000 tons of uranium had been already proved ; each ton is theoretically the equivalent of 3,000,000 tons of coal in producing heat (although probably not more than a third of this could be practically extracted). One million million tons of coal equivalent will last the world for many years, nor is there the least reason to suppose that there is not much more uranium available. At present figures the cost of the uranium is a small part of the cost of the new power, which comes mainly from the cost of the installation and maintenance. Then there is thorium, which, though not immediately usable, can be turned into a very useful fuel by packing it round a reactor that is working. Even beyond these possibilities comes that of thermonuclear action. As you know, work is being done here and in the United States and in Russia to make commercial use of the energy that is released in the nuclear reaction between the nuclei of deuterium (heavy hydrogen), which is the basis of the hydrogen bombs. The difficulties are considerable, but the energy, as is only too well known, can be released explosively. I have no doubt that in the not very distant future it will be tamed, and used for peaceful purposes. Whether it will greatly improve on uranium and thorium remains to be seen. It will depend on how complex the devices have to be to release it. In the long run I think it may win, as I believe that there is much more possibility of deriving electrical energy directly from a nuclear reaction in the case of deuterium than in the case of uranium, and this would save the inefficiency of the heat engine that now interposes itself. It is also possible that a combination of the two might prove economic. The deuterium reaction produces neutrons—these might be used to turn uranium into plutonium, or thorium into uranium 233, thus producing very valuable material which can be used to enrich normal uranium.

The reactors proposed in the first stage of the British proposals will work with normal uranium, or with uranium only slightly enriched with special fissile material such as plutonium or separated uranium 235, but as the art progresses and supplies of these substances become more readily obtainable, there is little doubt that we shall tend towards the use of highly enriched material. Already the experimental plant at Dounreay in the North of Scotland is designed to do so.

I might perhaps refer to some of the limitations of nuclear power. The chief one is that it necessarily produces at the same time a large amount of radiation, which is harmful to health, hence this has to be shielded, and the shielding is necessarily cumbrous. There seems no way out of this —I do not see the slightest hope for the nuclear motor-car. I have grave doubts about the nuclear aeroplane ; its sole advantage is that it would save the weight of fuel. For a very long trip it might pay, but such long trips are only needed in war. For crossing the Atlantic, I do not believe that the saving in the weight of fuel would compensate for the weight of the shield, and the increased complexity of the machinery, at least in an aeroplane of anything like the present size.

Radioactive Isotopes

A minor application of nuclear energy, but minor only in comparison with what we have just been speaking of, is that of radioactive isotopes. Radioactive isotopes are atoms belonging to some normal chemical element, from which they are indistinguishable chemically, but which have, in addition, radioactive properties. A few of them are used for chemical purposes as substitutes for radium, but much the most important use is as tracers, that is, as labelled atoms. If some are mixed with normal atoms of the same species, then the path of these normal atoms can be followed from observing the radioactive isotopes, for since they are chemically similar they will follow a similar path. The uses of these isotopes are innumerable in medicine, biology, and in engineering. It will be enough to give just two examples, one from medicine and one from engineering. It may be important in diagnosis to determine the rate of flow of blood ; for example, where it is suspected that there is restriction, as in thrombosis, sodium 24 is used for this purpose. If a constriction is suspected in the leg, a Geiger counter is placed on the patient's hip, and an active sodium chloride solution injected into a vein in his foot ; the interval of time that elapses between the moment at which the injection is given and that at which the counter begins to respond shows how long it has taken the blood to flow up the leg, and this can be compared with the time for the other, normal leg.

In engineering, if you wish to measure the wear of a bearing rapidly and accurately, you can incorporate an isotope into the metal of the bearing, and measure the radioactivity which is carried away in detritus by the oil.

Electronic Computers

The next scientific application of which I want to speak is as much an application of mathematics as of physics, but both, after all, are in Section A. I mean the electronic computer. An electronic computer cannot be dropped as a bomb, and so has not quite made the headlines in the way nuclear energy has done, but I believe it is comparable in importance. The ability to apply precise reasoning to very large amounts of data in a reasonable time is something new, and the powers that it gives are still not appreciated properly. The introduction of electronic computers into science may prove not much less important than the introduction of mathematics in the seventeenth century. This seems odd when one recalls that all an electronic computer does is to add or substract—even its multiplication is done, in principle, by successive additions. Its importance comes in two ways. Firstly it is possible to alter the instructions, which are coded in numbers like the numerical data, by what comes out as the result of a calculation. You can, for example, make the machine do different things according to whether the answer to a particular sum is even or odd, by adding the last digit of the answer to a number which represents the instruction telling the machine what next to do. It has, to this extent, the power of discrimination, of being influenced, that is, by what it has itself found ; this gives it great flexibility. The other reason for its great importance is simply its speed and the consequent enormous number of operations which it can perform in a given time. Its versatility is enormous. Apart from the obvious applications to mathematics, to physics, and to chemistry, it is needed for work in genetics, in aeronautics, in textiles, in social medicine, in agriculture, even in anatomy, though I am not sure what it is proposed to do with it there ! It has recently been applied to meteorology to calculate the weather, by an application straightforward in principle, but difficult to apply, of the laws of dynamics, to the movements of masses of gas. This is at present being done both in Britain and in America. A more mundane application is to commerce, to the calculation, for example, of pay due to employees, and other administrative purposes where a great many sums

nave to be done within a limited time. It may do much to take drudgery out of the office, and be to the clerk what the bulldozer is to the navvy.

Transistors

Then there is the new discovery of the transistor. This is a device replacing the thermionic valve by a minute slice of duranium or silicon. It was originally discovered in America by Shockley and Bardeen, and its possibilities quickly appreciated. It depends on the small degree of conductivity of germanium due to the presence of a few free electrons, or what are called holes—places from which an electron that ought to be there is absent. The movement of these constitutes a current which can be controlled by electric fields, and the transistor can do the work of the normal free-electron valve. Its advantage is that it is enormously smaller and requires no hot filament. It will make possible a great reduction in size, and probably in cost, of all electronic gear. Though Bardeen and Shockley were employees of Bell Telephone Laboratories, America, at the time they made the discovery, they were working on the problem purely for its scientific interest, and the application was unforeseen till the discovery was made.

Earth Satellite

Finally I should like to say something about the proposed satellite which the United States are hoping to send up next year. It is an admirable example of the interplay of physics and technology. On the one hand, its immediate purpose is to make measurements outside the earth's atmosphere. On the other hand, it is the first stage in what one hopes will be the overcoming of gravity, in the sense of making it possible for men to leave the earth and visit other planets. Further, the rockets which drive it depend on principles which were developed mostly for war purposes. It will be launched by a three-stage rocket, and it is hoped that when the last stage has finished firing it will be moving at a height of about 300 miles round the earth, with a speed of nearly 18,000 m.p.h., which would ideally enable it to move in a circular orbit round the earth. Small errors in the final velocity, either in magnitude or direction, will result in an elliptic orbit which will, if more than of a very small eccentricity, result in its approaching the earth at perigee a good deal nearer than 300 miles. This will result in its being rather seriously slowed down by the just appreciable amount of air that it will find, and so will reduce its lifetime. But ideally it ought to be able to stay up for a matter of weeks, very slightly spiralling in towards the earth as its speed is slowed down by the very minute amounts of air that it will find. All the time, this sphere of 25cm diameter will be sending messages to the earth of the measurements that it is taking of the radiation of all kinds that it receives. It may even be able to verify experimentally some of the laws of relativistic gravitation, the changing rate of a clock in particular.

Thus physics and mathematics are becoming more and more important in technology. Branches of technology are arising which depend on new scientific discoveries, and inside existing technologies advances are being made in detail by using devices based on physics and methods which depend on mathematical, especially statistical, analysis.

It is of the greatest importance that more young people should be trained in these sciences, both for their own future advancement and for the good of the country.

Combined Stress Creep Fracture of a Commercial Copper at 250 Deg. Cent

By A. E. JOHNSON, D.Sc., M.Sc.Tech., M.I.Mech.E., J. HENDERSON, B.Sc., and V. D. MATHUR, B.Sc.

No. II—(*Concluded from page 265, August 24th*)

The tertiary creep and fracture characteristics of a commercially pure copper at 250 deg. Cent. are examined. Some fifteen combined tension and torsion, pure tension, pure torsion and pure compression creep tests have been made on the copper at 250 deg. Cent. and the results analysed. The conclusions reached are that in the case of the commercially pure copper at 250 deg. Cent. all fractures under complex stress creep conditions, including pure tension and pure torsion, are overwhelmingly intercrystalline in nature. Satisfactory evidence was obtained to indicate that the Siegfried hypothesis that intercrystalline fracture is due to hydrostatic stress is incorrect for this material. It would appear that the period to creep fracture is purely a function of the maximum tensile principal stress. No other reasonably possible stress criterion is in accord with the results. A continuous relation between octahedral stress and average octahedral strain rate over the whole period of the test to fracture, as suggested by Kochendorfer, does not exist for this material. It was indicated that for the great majority of tests an equation of type $\epsilon_0 = At^n + Be^{Kt}$ represents the complete creep curve, At^n corresponding to primary creep and Be^{Kt} to tertiary creep. In the tests at particularly low stress levels and long fracture periods, however, the equation does not adequately represent the whole creep curve although the tertiary creep when fully established follows a relation of type $\epsilon_{0t} = Be^{Kt}$. No evidence was obtained of stress dependence in the case of the characteristic B.

(*d*) *The Stress Dependence of Tertiary Creep Preceding Fracture.*—The Kochendorfer criterion in its initial and general form postulates that continuous relations between a reference strain proportional to octahedral strain, and a reference stress proportional to octahedral stress, which are known to hold closely for primary creep of a number of metals and alloys, may be extended to characterise the total creep (primary plus tertiary) up to fracture. It appears that such relations have been shown to hold for the yielding and fracture at elevated temperatures of a number of ductile materials. It is perhaps not unreasonable, therefore, to

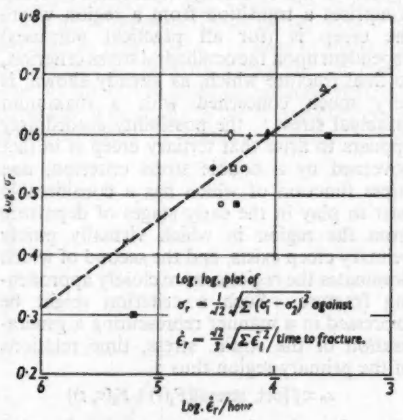


Fig. 18—Application of Kochendorfer criterion to tests on commercially pure copper at 250 deg. Cent.

make the suggestion as Kochendorfer has done that such relations might be extended or modified to characterise the case of creep fracture. He, in fact, suggested that for the case of creep the reference average strain rate to fracture

$$\left\{\text{defined as } \dot{\epsilon}_r = \frac{\sqrt{\frac{2}{3}}\sqrt{\Sigma\epsilon_1^2}}{\text{Total time to fracture}}\right\}$$

and not the simple reference strain at fracture should be used to characterise the relations. Accordingly, the application of this criterion to creep fracture has been considered by the authors in relation to the creep of copper at 250 deg. Cent., and in Fig. 18 a plot of the reference stress against $\dot{\epsilon}_r$ is given for all stress systems.

This figure needs some detailed consideration, since it indicates neither a complete discontinuity nor a very satisfactory continuity. First, the three points corresponding

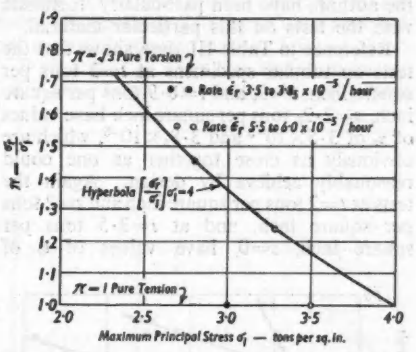

$\pi = \sqrt{3}$ Pure Torsion
Rate $\dot{\epsilon}_r$ 3·5 to 3·8 $\times 10^{-5}$/hour
Rate $\dot{\epsilon}_r$ 5·5 to 6·0 $\times 10^{-5}$/hour
Hyperbola $\left[\frac{\sigma_t}{\sigma_1}\right]\sigma_1 = 4$
$\pi = 1$ Pure Tension
σ_t/σ_1
Maximum Principal Stress σ_1 — tons per sq. in.

Fig. 19—Application of Kochendorfer criterion to tests on commercially pure copper at 250 deg. Cent.

to the solid tensile test pieces form a group considerably separate from the points corresponding to the tubular specimens, and in themselves appear to point to a continuous relation. However, consideration of the points corresponding to the tubular specimens does not give quite so simple an indication.

The points corresponding to the highest and lowest values of σ_r may be joined by a line, the slope of which is actually the same as that of the log. octahedral stress log. creep rate line in the plot for specific periods of primary creep. This line passes more or less diagonally through the points corresponding to the other σ_r values involved, but the disposal of these remaining points in relation to each other and the line is by no means in conformity with the idea of a continuous relation.

To make an examination of the criterion

KEY TO SYMBOLS USED ON GRAPHS.

•	Pure torsion 2 tons per sq. in.			○	Pure tension 3 or 3·5 tons per sq. in.		
+	Tension 2 tons per sq. in.	.....	Torsion 2 tons per sq. in.				
□	do. 3	do.	.....	do. 1	do.		
×	do. 2	do.	.....	do. 1	do.		
◊	do. 0·9	do.	.....	do. 2·25	do.		
◆	do. 3	do.	.....	do. 1·5	do.		
△	do. 2·3	do.	.....	do. 2·3	do.		

■ Solid specimen: Tension 4, 3 and 2 tons per sq. in.

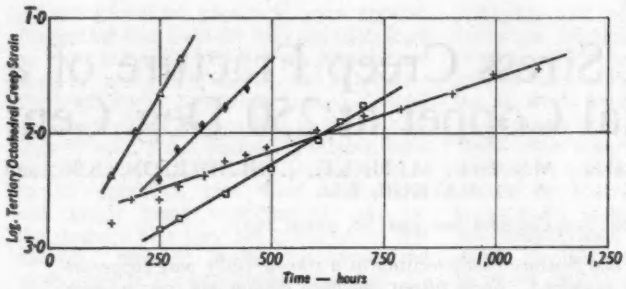


Fig. 20—Relation log. tertiary octahedral creep strain-time plot of combined stress tests of thin-walled tubular specimens of commercially pure copper at 250 deg. Cent.

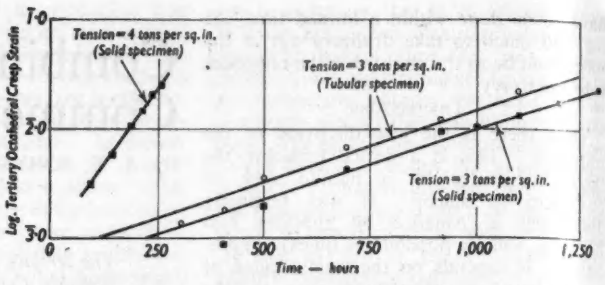


Fig. 21—Relation log. tertiary octahedral creep strain-time plot for solid and thin-walled tubular specimens of commercially pure copper at 250 deg. Cent.

more explicit we will consider a plot suggested as a check of the validity of the criterion by Kochendorfer himself. He suggested that for a specific reference strain rate $\dot{\epsilon}_r$, the ratio $\frac{\sigma_r}{\sigma_1}$ (denoted by the symbol Π) be plotted against the maximum principal stress σ_1. If the Kochendorfer criterion be valid this will give a hyperbola $\left[\frac{\sigma_r}{\sigma_1}\right]\times[\sigma_1] = K$, where K is the value of the reference stress, which, according to the criterion, corresponds to the reference strain rate $\dot{\epsilon}_r$. Accordingly, to obtain a check of the criterion, it is desirable to obtain a number of tests for which the average rate $\dot{\epsilon}_r$ is virtually the same, and to compare the ratio $\frac{\sigma_r}{\sigma_1}$ with σ_1 for these tests. Naturally, it is particularly difficult to arrange *a priori* that a test should give a specific creep rate $\dot{\epsilon}_r$, but in this respect the authors have been particularly fortunate with the tests on this particular material.

Reference to Table III, *ante*, shows that the tests on tubular specimens at $t=3$ tons per square inch, $s=0$, and $t=0{\cdot}9$ tons per square inch, $s=2{\cdot}2_5$ tons per square inch have values of $\dot{\epsilon}_r$ of $3{\cdot}5\times10^{-5}$ and $3{\cdot}8_5\times10^{-5}$, which are obviously as close together as one could reasonably achieve by design. Again the tests at $t=2$ tons per square inch and $s=2$ tons per square inch, and at $t=3{\cdot}5$ tons per square inch, $s=0$, have values of $\dot{\epsilon}_r$ of

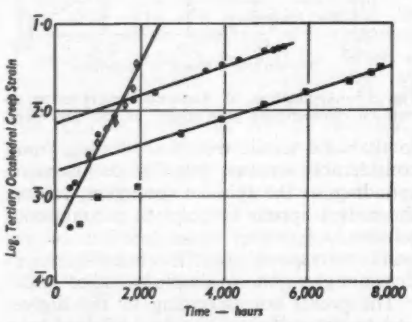


Fig. 22—Relation log. tertiary octahedral creep strain-time plot for solid and thin-walled tubular specimens of commercially pure copper at 250 deg. Cent.

$5{\cdot}5\times10^{-5}$, and 6×10^{-5}, to which pair of tests the same remarks apply. The values of σ_r, σ_1, and $\frac{\sigma_r}{\sigma_1}$ are listed in Table IV, *ante*, with the values of $\left[\frac{\sigma_r}{\sigma_1}\right]\times[\sigma_1]=K$ for the tests $t=0{\cdot}9$ tons per square inch, $s=2{\cdot}2_5$ tons per square inch and $t=2$ tons per square inch $=s$. It will be seen that $K=4$ for both these tests. Accordingly two tests having values of $\dot{\epsilon}_r$ roughly in a two to one ratio lie upon the same hyperbola; this result is contrary to the requirements of the Kochendorfer criterion. In Fig. 19 the plot for all four tests is made of $\frac{\sigma_r}{\sigma_1}$ against σ_1, and the hyperbola $\left[\frac{\sigma_r}{\sigma_1}\right][\sigma_1]=4$ is drawn through the points corresponding to tests $t=0{\cdot}9$ tons per square inch, $s=2{\cdot}2_5$ tons per square inch, and $t=2$ tons per square inch, $s=2$ tons per square inch. The points corresponding to the tests $t=3$ tons per square inch, $s=0$, and $t=3{\cdot}5$ tons per square inch, $s=0$, are seen to lie well away from the hyperbola; this completes the evidence upon which the

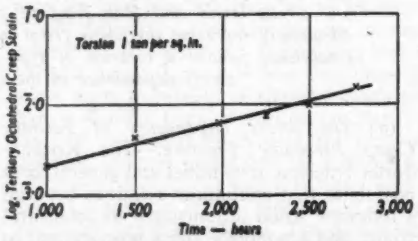


Fig. 23—Relation log. tertiary octahedral creep strain-time plot for combined stress creep test on thin-walled tubular specimen of commercially pure copper at 250 deg. Cent.

application of the Kochendorfer criterion to these particular circumstances must be rejected.

Considering generally the stress dependence of tertiary creep, two major possibilities appear to exist. Firstly, since tertiary creep comprises a transition from a region where the creep is (for all practical purposes) dependent upon the octahedral stress criterion, to final fracture which, as already shown, is very much concerned with a maximum principal stress: the possibility accordingly appears to arise that tertiary creep is in fact governed by a double stress criterion, one stress function of which has a considerable part to play in the early stages of departure from the region in which virtually purely primary creep exists, and the second of which dominates the regions more closely approaching fracture. Such a criterion might be expressed in a manner representing a generalisation of the strain, stress, time relations of the primary region thus:

$$\epsilon_0 \propto f[\text{oct. stress}][F_1(t)+F_2(\sigma,t)]$$

where f is a function, F_1 a pure time function corresponding to primary creep and F_2 a mixed stress, time function corresponding to tertiary creep.

From the second point of view, the tertiary creep might be regarded as representing a newly operating mechanism of creep arising from and coexisting with continuing primary creep, but not directly linked with its characteristics. Such a conception might be consistent with representation of the type

$$\epsilon_0 \propto \{f[\text{oct. stress}][F_1 t]+F_2(\sigma,t)\}.$$

This equation and the previous one may be represented by one equation

$$\epsilon_0 \propto \{f[\text{oct. stress}][F_1 t]+BF_2(\sigma,t)\},$$

where in the first case B is a function of octahedral stress and in the second a numerical constant. It is to be noted that the above equations, while representing the geometrical symmetry of creep strain-time curves normally noted in primary creep, indicate a departure from the symmetry in tertiary creep.

Unfortunately, a third factor enters into consideration when strains of the order associated with tertiary creep, and ultimate fracture are considered. This is the development of anisotropy. Previous work has indicated that under complex stress systems material initially isotropic develops anisotropy at stresses or periods sufficiently large to give considerable strain, and that the degree of this anisotropy depends in general on the stress system. Accordingly, a very complicated position arises when a group of tests of various stress systems and lasting various periods of time to fracture is considered in that anisotropy which, in general, accompanies tertiary creep becomes appreciable at various periods, and the degree of the anisotropy in general depends upon the actual stress system imposed. In general, therefore, in the worst case the tertiary creep characteristics (particularly those represented loosely by B) may virtually apply to a material modified by anisotropy in differing degrees in each separate test. In this case it may be difficult from consideration of a group of tests to derive tertiary creep characteristics.

Nevertheless, it is useful to examine what

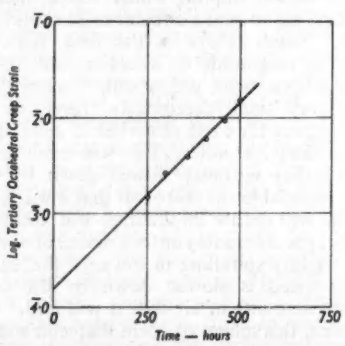


Fig. 24—Relation log. tertiary octahedral creep strain-time plot for thin-walled specimen of commercially pure copper at 250 deg. Cent.

information can be obtained from the current tests and also those preceding them on 0·5 per cent molybdenum steel at 550 deg. Cent. In the previously quoted paper dealing with the 0·5 per cent molybdenum steel, it was shown that the whole creep curve, including primary and tertiary creep, could for each test be well represented by a general equation:

$$\epsilon_0 = C[K_1 t + At^n] + Be^{Kt},$$

the first term on the right-hand side applying to primary creep and the second to tertiary creep. Both in the primary and tertiary creep ranges, judged by the ratio of axial

and shear creep strain, the material was markedly anisotropic. Accordingly, the values of B and C were modified by this anisotropy although the values of K_1, A, and n, were the same for all tests, and K_2 varied with the stress system in a manner which, as will be shown in later paragraphs, was independent of anisotropy. It became evident that C was a power function of octahedral stress, but on the other hand it was not possible to relate B directly to any stress function ; and judgment was suspended

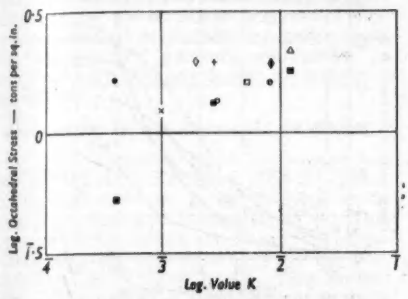


Fig. 25—Tertiary creep value of K in relation octahedral strain $=Be^{Kt}$ for commercially pure copper at 250 deg. Cent.

with the two possibilities in mind that the B's were either anisotropic stress functions or simply anisotropic numerical constants. In either case the sparseness of data (three complex stress tests only were made) would have prevented further resolution of the matter.

For the 0·5 per cent molybdenum steel values of K were obtained with considerable precision by plots of log. (total creep strain—less primary creep strain) against time ; this gave linear curves of very definite slope. The stress dependence of these values of K will be mentioned in a later paragraph when corresponding values for copper are considered. In view of the fact that the primary creep portion of the total creep strain arising in the tests on copper at 250 deg. Cent. was adequately represented by means of an expression generally similar to (although more simple in detail) than that

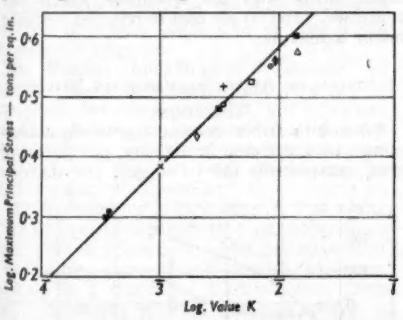


Fig. 26—Relation between maximum principal stress value of K in the relation tertiary creep strain $=Be^{Kt}$ for commercially pure copper at 250 deg. Cent.

corresponding to the 0·5 per cent molybdenum steel at 550 deg. Cent., it seemed reasonable to examine whether the tertiary creep could be represented by a similar function to that applying to the 0·5 per cent molybdenum steel. Accordingly, in Figs. 20–24 a plot is given for the various tests on copper at 250 deg. Cent. of log. octahedral strain against time for tertiary creep strain only (octahedral strain is here used conveniently as an invariant of creep strain, and has no other significance). In all cases the plots eventually became linear, and it became evident that established tertiary creep could be represented by a term Be^{Kt}.

The question next arises whether the whole creep curve can be represented by the sum of the terms found adequate in the primary and tertiary ranges or

$$\epsilon_0 = At^n + Be^{Kt}.$$

Table V, *ante*, gives a survey of the characteristics of the curves in relation to this equation. It is evident that, except in three cases, the whole curve can be represented by this equation and the appropriate values of A, n, B and K are given in the Table V. The three exceptions are the tests at $t=2$ tons per square inch, $s=1$ ton per square inch ; $t=0$, $s=2$ tons per square inch and the test on a solid specimen* at $t=2$ tons per square inch, $s=0$. These three tests have two features in common. They are at relatively low stresses, and last relatively long periods to fracture. It appears that it is possible that in these conditions the physical circumstances of tertiary creep represented by the terms Be^{Kt} are slow in developing, and there is virtually a secondary

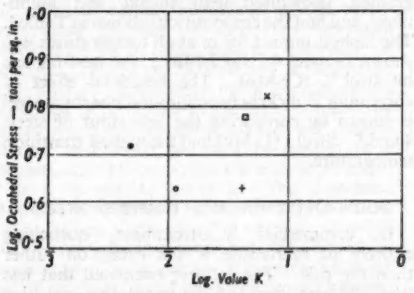


Fig. 27—Tertiary creep value of K in relation octahedral strain $=Be^{Kt}$ for 0·5 per cent molybdenum steel at 550 deg. Cent.

region between purely primary creep and the onset of the tertiary creep proper. However, without micrographical evidence it is useless to speculate on this point, but it is obviously a matter for examination in future work.

It remains to examine the nature of K and B.

As in the case of the 0·5 per cent molybdenum steel at 550 deg. Cent., the values of K are quite precisely given by the slopes of the lines in Figs. 20–24. In view of the stress dependence of primary creep and of creep time to fracture it appears unlikely that the stress dependence of K is other than maximum principal stress or octahedral stress. (The

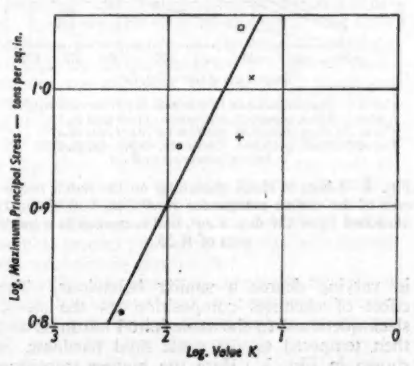


Fig. 28—Relation between maximum principal stress and value of K in the relation tertiary creep strain $=Be^{Kt}$ for 0·5 per cent molybdenum steel at 550 deg. Cent.

same remarks, of course, apply to B.) Accordingly, in Figs. 25 and 26 log. K is plotted against log. octahedral stress and log. maximum principal stress. From Fig. 25 it is immediately obvious that K has no continuous relation with octahedral stress. On the other hand, Fig. 26 shows that the relation with maximum principal stress is both continuous and precise, being on the log.–log. plot virtually linear. Further, in Figs. 27 and 28 corresponding plots are shown for the 0·5 per cent molybdenum steel at 550 deg. Cent. Again, the relation with octahedral stress is discontinuous. However, the relation with maximum principal stress, although showing some scatter of the points,

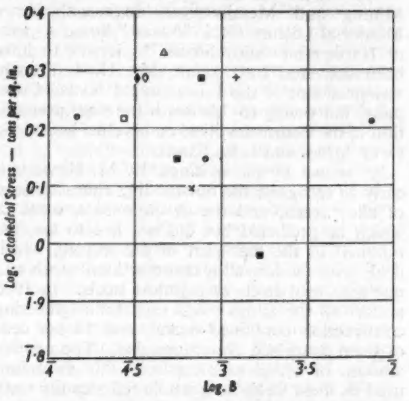


Fig. 29—Relation between function B and octahedral stress for tertiary creep

is reasonably continuous and if the best mean line is drawn through the points it is seen that this line has precisely the same slope as the line in Fig. 26 for the copper at 250 deg. Cent.

Accordingly, the important conclusion emerges that the exponent of K of the tertiary creep term is explicitly a function of maximum principal stress, and is the same function (except for an arithmetical constant) in the cases of copper at 250 deg. Cent., and 0·5 per cent molybdenum steel at 550 deg. Cent.

With regard to B, values for the copper at 250 deg. Cent. are plotted log.–log. plot

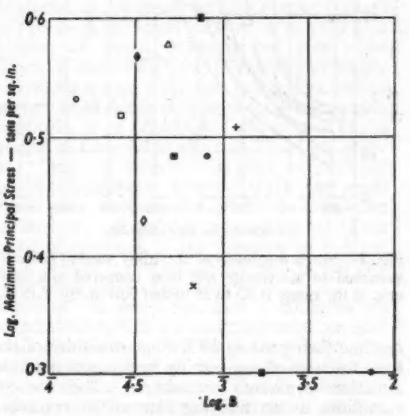


Fig. 30—Relation between function B and maximum principal stress for tertiary creep

in Figs. 29 and 30 against octahedral stress and maximum principal stress. No suggestion whatever of continuity is provided, and accordingly the present set of results, like those of the 0·5 per cent molybdenum steel at 550 deg. Cent., gives no indication of stress dependence of B. It appears quite possible that the B's are in fact numerical constants corresponding to complex states of anisotropy; no obvious means of confirming this suggests itself, but the matter is to be given attention in future work.

Summarising, it appears that while the Mises criterion of plastic flow characterises primary creep a most important part in the development of tertiary creep towards eventual failure is played by the maximum tensile principal stress, presumably through the medium of the propagation of cracks, incipiently created by primary creep.

* It is interesting to note that it has a different value for tubular as compared with solid specimens.

Metallurgical Topics

Alloy Steels

THE subject of the American Institution of Mining and Metallurgical Engineers' Howe Memorial Lecture for 1956 was "Some Aspects of Hardenable Alloy Steels."* It was to have been delivered by the late Mr. H. J. French, vice-president of the International Nickel Company, but owing to his death the final preparation of the lecture devolved on his chief assistants, O. O. Miller and J. W. Sands.

As shown by his writings, H. M. Howe was early to recognise the outstanding characteristics of alloy steels, and the developments, some of which he predicted but did not live to see, are outlined in the first part of the lecture, which deals with the low-alloy constructional steels and not with tool steels or stainless steels. In 1900 almost all the alloys steels used for engineering construction contained nickel, and 10 per cent of them contained chromium also. The relative amount of nickel as compared with chromium used in these steels as a whole fell steadily until 1920, after which it remained more or less constant until about 1943, when the proportion of nickel used again fell owing to war shortages, and it has only recently begun to rise again. In 1905 steels containing vanadium made an appearance in engineering construction and for fifteen years steadily grew more popular. They

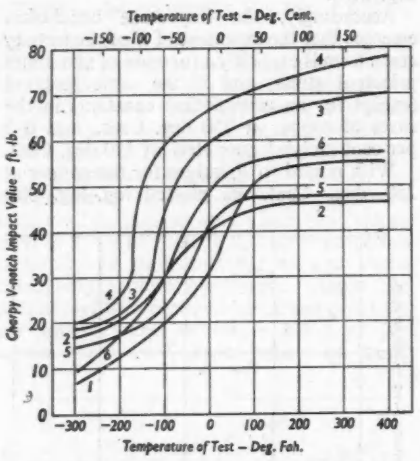

Temperature of Test – Deg. Cent.
−150 −100 −50 0 50 100 150
Charpy V-notch Impact Value – ft. lb.
80 70 60 50 40 30 20 10 0
−300 −200 −100 0 100 200 300 400
Temperature of Test – Deg. Fah.
4 3 6 1 5 2

Fig. 1—Notch toughness of six alloy steels (Table I), quenched to martensite and then tempered to a hardness in the range R_c33 to 35 (about 330 to 350 V.D.H.)

reached their peak in 1920 when one-third of the total tonnage of engineering steel ingots made in America contained vanadium. The use of vanadium as an alloying element in constructional steels began to decline with the introduction of molybdenum steels, the output of which grew rapidly. Thus, between 1920 and 1950 the predominant feature was the increased proportion of steels containing molybdenum with accompanying decline of the vanadium steels, while the parts played by nickel and chromium varied much less. A great increase in the use of molybdenum occurred in 1940, as it was introduced into many steels to replace part of the nickel and chromium, giving the nickel-chromium-molybdenum National Emergency steels. Boron came into use in 1941. Its use reached a peak in 1952. This was followed by what seems to be some evidence of a decline.

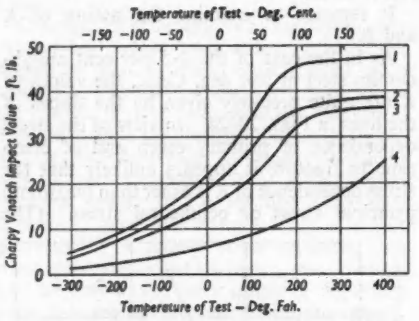
Fully Hardened and Tempered Steels

After paying a tribute to the value of rapid hardenability measurements as a successful means of approach to the problem of maximum conservation of alloying elements in time of heavy consumption, the lecturer referred to "the development in America of the philosophy that hardenability is the dominant factor, and that the mechanical properties of all tempered martensites of the same hardness and carbon content are alike, irrespective of the percentage of other elements." This erroneous idea was held to have resulted from too broad an interpretation of the work on hardenability, and from ignoring the restrictions which workers on hardenability had put on the application of their own conclusions. Results were then given to show how steels, quenched to martensite and tempered to the same hardness, differ in notch-tensile strength and in notch toughness according to their composition. Results given in Fig. 1 show that considerable differences exist in the notch toughness of tempered martensites of the same hardness but of different composition. The steels used were fine-grained, deoxidised with silicon and aluminium, and had the compositions shown in Table I. The highest impact figure at all temperatures was shown by steel 4 (Ni-Cr-Mo); the next highest by steel 3 (Cr-Mo). The beneficial effect of chromium in nickel-chromium-molybdenum steel is shown by comparing the behaviour of steels 4 and 5. Steel 1 (C-Mn) had the highest transition temperature.

Slack-Quenched and Tempered Steels

In commercial heat-treatment, quenching entirely to martensite is the exception rather than the rule. The lecturer estimated that less than 20 per cent of representative machine parts made in America were quenched almost completely to martensite before tempering. The martensite is usually diluted with a fair proportion of transformation products, and the initial hardness of the steel is thereby lowered.

The very pronounced effect of slack quenching on the transition temperature of steel 1 (C-Mn) is shown in Fig. 2. The other steels would show


Temperature of Test – Deg. Cent.
−150 −100 −50 0 50 100 150
Charpy V-notch Impact Value – ft. lb.
50 40 30 20 10 0
−300 −200 −100 0 100 200 300 400
Temperature of Test – Deg. Fah.
1 2 3 4

Curve 1—Water-quenched to martensite, 100 per cent R_c58
Curve 2—Slack quenched, martensite, 80 per cent R_c51
Curve 3—Slack quenched, martensite, 70 per cent R_c47
Curve 4—Slack quenched, martensite, 40 per cent R_c40 before tempering to R_c35.

Fig. 2—Effect of slack quenching on the notch toughness of the carbon-manganese steel (No. 1 in Table I) quenched from 830 deg. Cent. and tempered to a hardness of R_c35

in varying degree a similar behaviour. The effect of chemical composition on the steels, slack-quenched to the same initial hardness and then tempered to the same final hardness, is shown in Fig. 3. Here the highest transition temperature is again shown by steel 1 (C-Mn), and the lowest by the low-chromium nickel-chromium-molybdenum steel (5). As compared with Fig. 1, the position of the high-chromium and the low-chromium nickel-chromium-molybdenum steels (4 and 5) is reversed, and the less beneficial effect of chromium in the slack-quenched steels is also shown by the positions

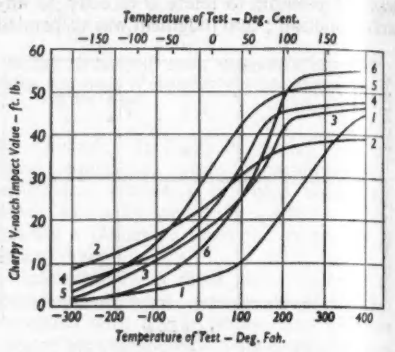

Temperature of Test – Deg. Cent.
−150 −100 −50 0 50 100 150
Charpy V-notch Impact Value – ft. lb.
60 50 40 30 20 10 0
−300 −200 −100 0 100 200 300 400
Temperature of Test – Deg. Fah.
6 5 4 1 3 2

Fig. 3—Notch toughness of six alloy steels (Table I), slack quenched to R_c40 and tempered to R_c32 to 35

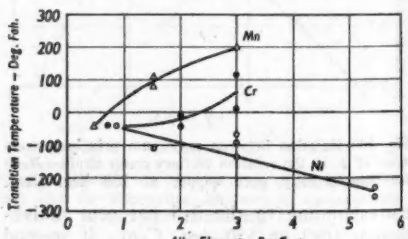
of steels 3 and 6 in the two diagrams. In both conditions the nickel steel (2) showed the least fall in impact value at very low temperatures. Comparison of Figs. 1 and 3 shows the general rise in transition temperatures due to slack quenching. The magnitude of the rise is significant as an indication of the relative performance to be expected from the differently treated steels under severe conditions of use.

After-Effect of Retained Austenite

The effect of retained austenite in the quenched material on the properties of the tempered steel was briefly referred to, and was examined in the modified nickel-chromium-molybdenum steel (7), which contained 1·57 per cent of silicon and 0·07 per cent of vanadium. The impact figure/temperature curves of specimens which had contained 2·5, 5 and 10 per cent of retained austenite before being tempered to the same hardness were nearly identical, the advantage in low-temperature notch toughness, although very slight, being with the specimens which had contained 5 and 10 per cent of retained austenite before tempering.

Effect of Alloy Elements on Notch Toughness

Increase in carbon content is generally accompanied by a decrease in ductility, but published data unexpectedly fail to suggest any decrease



Basic analysis, per cent, C 0·21 to 0·27, Mn 0·50, Si 0·30, Ni 0·85, Cr 0·70, Mo 0·50, V 0·10

Fig. 4—Effect of three alloy elements on the Charpy V-notch transition temperatures taken as 50 per cent of the maximum energy

TABLE I—*Composition of Steels, Per Cent*

No.	Steel	S.A.E.	C	Mn	Si	Ni	Cr	Mo	V	Al†	N
1	C-Mn	1340	0·43	1·79	0·24	0·11	0·07	Nil	—	0·020	0·006
2	Ni	2345	0·44	0·83	0·26	3·55	0·06	0·03	—	0·055	0·008
3	Cr-Mo	4140	0·41	0·82	0·23	—	0·95	0·16	—	0·018	0·005
4	Ni-Cr-Mo	4340	0·40	0·82	0·29	1·72	0·85	0·25	—	0·017	0·010
5	Ni-Cr-Mo	4640	0·42	0·76	0·24	1·78	0·18	0·26	—	0·032	0·010
6	Cr	5145	0·45	0·66	0·17	0·04	0·95	0·02	—	0·024	0·001
7	Ni-Cr-Mo	4340*	0·38	0·77	1·57	1·82	0·84	0·32	0·07	0·027	—

* Modified. † Acid soluble; Al_2O_3 not included.

* *Journal of Metals*, June, 1956, page 770.

n transition temperature when the carbon content falls below 0·40 per cent. The work of C. C. Busby, H. W. Paxton and M. F. Hawkes† showed the effect of increasing manganese, nickel and chromium on the transition temperature of a nickel-chromium-molybdenum steel in a high-tensile condition. The sixteen fine-grained steels used for Fig. 4 were quenched to martensite and tempered to hardnesses within the range R_c 49 to 54 (about 520 to 600 V.D.H.). The curves show that the transition temperature is greatly increased by manganese, increased a little by chromium and lowered considerably by nickel. An unexplained reversal of the effect of manganese on the transition temperature may be noted, since in normalised low-carbon steels used for structural purposes, an increase in manganese very definitely lowers the transition temperature.

Advantages of the Triple Alloy Steels

The data presented in the lecture suggest that the properties of the triple alloy nickel-chromium-molybdenum steels are, in general, superior to those of the double or single alloy steels. This is regarded in the lecture as a happy coincidence because the triple alloy steels allow for the most efficient use of the alloys for imparting hardenability. The amount of these elements in scrap continues to increase, and conservation is, therefore, greatly aided by concentration on the triple alloy grades with or without vanadium and boron.

High-Purity Chromium

High-purity chromium is needed for the production of chromium-rich alloys with cobalt or nickel, suitable for resisting oxidation and corrosion under severe conditions, also for chromium carbide powder metal products and cermets for high-temperature service. The possibilities, hitherto unrealised except in small-scale laboratory experiments, of obtaining ductile chromium metal have also directed attention to the importance of the commercial production of chromium of the highest possible purity. Hitherto the main bulk of the metal has been obtained by electro-thermal reduction of oxide by silicon or aluminium, but the product rarely contained more than 98 per cent of chromium, iron and carbon with silicon or aluminium being the important impurities. The alumino-thermic process may yield chromium of over 99 per cent purity, but to achieve this the use of the best chemically-prepared chromium oxide and of high-purity aluminium is essential.

The Electro Metallurgical Company, of America, has been a commercial producer of electrolytic chromium since 1938, but only small quantities were made. A new plant at Marietta, Ohio, completed in 1954 and now in operation, is described as "The first commercial plant for electrowinning of chromium," in an article by M. C. Carosella and J. D. Mettler.* The source of the chromium is high-carbon ferro-chromium made in the electric furnace. The ground product is treated by a succession of chemical processes, resulting in a chromium alum solution, from which chromium of 99·8 per cent purity is electrodeposited in diaphragm cells.

Many kinds of special equipment are needed to withstand the severe conditions of corrosion which prevail throughout the chemical circuit. The development owed much to the work of the U.S. Bureau of Mines at Boulder City, Nev., and materials of construction suited to meet the special requirements of the process were investigated at Boulder City and at a pilot plant at Niagara Falls. The maintenance and safe operation of the electrolytic diaphragm cells also presented difficult problems owing to the corrosive character of the solutions, the necessary narrow limits of control of pH of the catholyte and of the operating temperature, and the serious consequences of any electrical interruption. The anodes were of lead containing 1 per cent of silver, and the cathodes of low-carbon austenitic stainless steel containing molybdenum. The cathodes were withdrawn at seventy-two-hour intervals, one-third of the total being withdrawn from each cell every day. The brittle cathode deposits, ¼in to ½in thick, were stripped off, the stripped metal crushed, washed with hot water, heated in stainless steel cans in an electrically heated furnace to dry and dehydrogenate the metal, and the cooled metal packed in sealed drums for transport. The toxic properties of chromic acid and chromates demand the provision of special precautions. The cells are completely covered and strongly ventilated to remove the hydrogen produced and to prevent chromic acid contamination of the atmosphere. The 99·8 per cent chromium contains as chief impurities iron 0·14, sulphur 0·025, carbon 0·01, lead 0·002, and copper 0·001 per cent. It is expected that further improvements will be made in the process, equipment and quality of the product.

Ductile Chromium

Meanwhile the problems associated with the production and properties of ductile chromium continue to receive attention in many quarters. The effect of certain impurities on the room-temperature ductility of chromium has been described by W. H. Smith and A. U. Seybolt, of the G.E.C. Research Laboratory, Schenectady, New York.† Tests were made on chromium containing a controlled nitrogen content by heating specimens containing 0·029 per cent of nitrogen and 0·003 per cent of oxygen in a nitrogen atmosphere to raise the nitrogen content or in a vacuum to lower it. The slow-bend transition temperature remained fairly constant at 0 to 50 deg. Cent. until the nitrogen exceeded 0·01 per cent and then increased. The transition temperature of the specimen containing 0·029 per cent of nitrogen, water quenched from 1200 deg. Cent., was 150 deg. to 200 deg. Cent. and slowly cooled in the furnace about 50 deg. Cent., indicating that nitrogen in solution was more harmful than chromium nitride. Their results confirmed those of Wain and his co-workers that oxygen was an insignificant factor in cold ductility. Tests were made on cast samples containing 0·02, 0·08 and 0·12 per cent of carbon with oxygen, nitrogen and sulphur all less than 0·005 per cent; 0·02 per cent was not detrimental but higher carbon gave considerably higher transition temperatures, increasing with increase in carbon content. It appeared that more than 0·02 per cent carbon could not be tolerated. On the other hand, sulphur in amounts as great as 0·1 per cent did not raise the transition temperature above that to be expected from material of the same composition without sulphur. Small additions of other metals to chromium raise the transition temperature, and the effect of additions intended to tie up harmful impurities was disappointing. By the addition of cerium, however, it was possible to lower the brittle to ductile transition temperature of chromium-containing nitrogen. A ductile condition at room temperature was not achieved, but the bend transition temperature of cast chromium containing nitrogen 0·03 to 0·07 per cent and oxygen less than 0·02 per cent was reduced from 150 deg. to 50 deg. Cent. by the addition of 2 per cent of cerium. Cerium does not prevent or nullify further contamination of the surface with nitrogen because it is present mainly as an insoluble second phase with an extremely limited solid solubility in chromium.

If ductile chromium and chromium-rich alloys are to be achieved on a commercial scale, electrolytic chromium would appear to be the only practicable starting material.

Corrosion of Steel

The effect of certain minor constituents on the corrosion of steel has been reported by F. Eisenstecken and W. Stinnes.* The tests were made on a total of seventy-three steels produced in 15 kg melts with Armco iron as the base and increasing sulphur (up to 0·22 per cent), manganese (up to 0·7 per cent), phosphorus (up to 0·5 per cent), and copper (up to 0·6 per cent). They were cast into hexagonal ingots, 90mm thick by 250mm long, forged to 35mm square bar and normalised. The specimens used were 40mm by 35mm by 4mm thick, cut longitudinally from the bar. The corrosion studies were carried out under natural conditions in rural and industrial atmospheres as well as by immersion in tap water and in artificial sea water, some specimens being immersed continuously and others for seven hours on five days of the week, the remaining time being in air. The duration of the experiments was usually twenty-seven months. The results were expressed as loss of weight in grammes per square metre per year, or as reduction of thickness in millimetres per year.

The conclusion was reached that the impurities sulphur and phosphorus in the amounts usually found in open-hearth and basic Bessemer steels had almost no influence on corrosion, no matter what method of corrosion testing was used. With increase in sulphur content above 0·06 per cent there was a marked increase in corrosion under all the conditions of testing employed, the corrosion being much greater in the presence of 0·7 per cent of manganese than when the manganese was only 0·1 per cent. This suggests that it is the manganese sulphide which is most active in promoting corrosion. With increasing phosphorus content corrosion diminished, both in the atmosphere and under conditions of intermittent immersion. The favourable influence of a high copper content in reducing atmospheric corrosion was confirmed. In immersion experiments, especially in artificial sea water, increase in copper content resulted in some decrease in corrosion. Addition of copper counteracted the harmful effect of sulphur in atmospheric corrosion, and to some extent also in tap water, but in intermittent immersion in sea water it was by no means so effective, though it did reduce the accelerating influence of increased sulphur. Similar conclusions applied to the beneficial effect of phosphorus on corrosion.

Some commercial steels were tested for comparison with the experimental series by means of intermittent tests in artificial sea water of twenty-seven months' duration. Armco iron with a reduction in thickness of 0·345mm per year showed the greatest loss of weight. The usual mild steels and steels with a high copper content (0·39 to 0·45 per cent) suffered a reduction in thickness of about 0·30mm per year. An addition of chromium (0·43 per cent) and copper (0·67 per cent) with 1 per cent manganese caused a further slight fall in corrosion loss. Increase in phosphorus or of phosphorus and copper in the steel had a favourable effect in these sea water tests. Thus, the experimental steel with 0·5 per cent of phosphorus (copper 0·07 per cent) suffered only about one-third of the corrosion loss shown by Armco iron, and even with 0·18 per cent of phosphorus in the presence of 0·3 per cent of copper a marked diminution in the rate of corrosion was to be observed.

Much of the work described is confirmatory of conclusions which have already been put into commercial practice, but the authors have provided fresh evidence of the beneficial effect of copper and of phosphorus in steel in combating certain types of corrosion. They point out that the effectiveness of different attendant elements in steel stands in close relationship with the formation of a protective layer on the surface of the metal.

Plastic Steel Jointing and Repairing Compound.—A compound known as "Devcon" plastic steel, which was developed in the United States, is being marketed in this country by E. P. Barrus (Concessionaries), Ltd., 12–16, Brunel Road, London, W.3. This compound is stated to consist of 80 per cent steel with 20 per cent plastic, and it was originally developed for making inexpensive tools and moulds, but its adhesive properties also made it particularly suitable for building up worn or broken parts of machines. Prior to use the plastic-steel compound is mixed with a hardening agent and it can be moulded to shape like clay. Once set, it is stated to become a tough metallic part, which rigidly adheres to the metallic body on which it is placed. The hardening process can be speeded by heating with a blow lamp or infra-red lamp. The compound is claimed to have a high resistance to abrasion, shrinks about 0·0005in per inch in setting and has a compression strength of over 18,000 lb per square inch. It is available in a putty-like form or as a viscous liquid in tins or bulk packages.

† *Trans. Amer. Soc. Metals*, 1955, Vol. 47, page 135.

* *Metal Progress*, June, 1956, page 51.

† *Journal of the Electrochemical Society*, June, 1956, page 345.

* *Archiv für das Eisenhüttenwesen*, July, 1956, page 469.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

THEORY OF HYDRODYNAMIC LUBRICATION IN PARALLEL SLIDING

SIR,—In his article "Theory of Hydrodynamic Lubrication in Parallel Sliding" (see issue of December 30, 1955), Mr. W. Lewicki points to an effect, here to be called the "inflow effect," that can generate pressure at the inlet of an oil film and that thus can create hydrodynamic load-carrying capacity even in a *parallel* oil film.

Although many years ago H. Brillié developed what he called in French "*bassins-relais*" (priming or boosting oil pockets) the action of which might well depend at least partly on the inflow effect, it would appear that he did not recognise the importance of this effect (cf., Brillié's paper "Contribution à l'étude des coussinets," Assoc. Techn. Maritime et Aéronautique, June, 1929). If only for this particular application, it would seem important enough to remove some of the uncertainties that are still inherent in Mr. Lewicki's analysis.

On the one hand, there is the approximation that has been termed the "polar approximation," and, on the other, that involved in the tacit assumption that the leakage from the inflow zone, through the inlet to the parallel film, would not affect the generation of pressure in this zone to any appreciable extent. A method, in which both approximations are avoided, embodies the successive solution of the problems to follow.

Problem No. 1.—Find, instead of the "polar approximation," an exact solution for the distribution of pressures in a sector-shaped inflow zone of which one of the bounding planes moves towards the apex of the sector, whilst there is no leakage at any point of these planes.

Problem No. 2.—Find the distribution of pressures in a sector-shaped inflow zone, both bounding planes being *stationary*, whilst leakage does occur, i.e. in the form of a point sink at the apex of the sector and at a flux strength q (this problem was not dealt with in the paper, not even in an approximate way).

Problem No. 3.—Superimpose the foregoing two solutions so as to arrive at a case which is here taken as representative of that depicted in Fig. 3, i.e. the case of a sector-shaped inflow zone having a point sink at its apex, whilst one of the bounding planes moves towards the apex. The actual sink, the inlet to the parallel film, is thus replaced, to some approximation, by a point sink or, what amounts to the same thing, by a sink in the form of some suitable arc around the apex.

The first two problems were solved by the present writer, for another purpose, some fifteen years ago. The mathematical technique will first be described concisely because it has not yet been published.

For deducing the exact solution to problem No. 1, it is convenient to rewrite the differential equations (1) in the polar co-ordinates r and θ, as indicated in Fig. 1. [References to Figures are to those in the original article —Ed. The E.] By then applying dimensional analysis to the influential factors p, η, U, and r, it is readily seen that only one dimensionless product can be formed from them, viz. $pr/\eta U$. It follows that this dimensionless product, unlike p itself, is no longer a function of r, but solely of θ. Obviously, the original number of the aforementioned variables (five) can thus be reduced to only two, both being dimensionless.

Similar findings apply to stream function ψ, which can likewise be regarded as a function of η, U, r, and θ.

By replacing the original variables in the partial differential equations (1) by the three new, dimensionless variables $pr/\eta U$, $\psi r^2/\eta q$, and θ, two *ordinary* differential equations are obtained, which can easily be solved. The exact solution obtained with the boundary conditions involved reads (p is here provided with the suffix 1 to distinguish it from the pressure p_2 in problem No. 2 yet to be treated; β, as in the paper, represents the sector angle):

$$\frac{p_1 r}{\eta U}=\frac{2}{\beta^2-\sin^2\beta}\cdot[\beta\cdot\sin\theta-\sin\beta\cdot\sin(\beta-\theta)] \quad . \quad . \quad . \quad . \quad . \quad (a)$$

According to this exact solution, pressure p_1, in contrast to Mr. Lewicki's "polar approximation" (13) does vary with θ. But at small enough sector angles β, this expression does reduce, to a good approximation, to formula (13), which could also have been deduced from Reynolds' theory of hydrodynamic lubrication and which no longer varies with θ.

In the particular case $\beta=\pi/2$ (square-faced slider or, say, quadrant-shaped inflow zone, as depicted in Figs. 1 and 2), where β is not particularly small, formula (a) assumes the following form, in which the variation of pressure p_1 with θ is far from negligible.

$$\frac{p_1 r}{\eta U}=\frac{8}{\pi^2-4}\cdot\left[\frac{\pi}{2}\cdot\sin\theta-\cos\theta\right] \quad . \quad . \quad (b)$$

The variation of p_1 can be judged from the values, at $\theta=0$ (moving plane), and $\theta=\pi/2$ (stationary plane) of the left-hand side of (b), viz. $8/(\pi^2-4)=1\cdot36$ and $4\pi/(\pi^2-4)=2\cdot13$, respectively. Both these values are lower than the constant value $24/\pi^2=2\cdot43$ of formula (9), but the maximum value, viz. $4(\pi^2\sqrt{\pi^2+8}+8)/(\pi^4-16)=2\cdot53$, which occurs at about $\theta=57\frac{1}{2}$ deg, is somewhat higher.

In what follows we shall use the average pressure $\bar{p}_1$, as averaged over the range $0\leqslant\theta\leqslant\pi/2$. This quantity is given by:

$$\frac{\bar{p}_1 r}{\eta U}=\frac{8}{\pi(\pi-2)}=2\cdot22 \quad . \quad . \quad . \quad . \quad (c)$$

The exact solution to problem No. 2 is found in an analogous manner and proves to be:

$$\frac{p_2 r^2}{\eta q}=-2\cdot\frac{\sin 2\theta+\sin 2(\beta-\theta)}{1-\cos 2\beta-\beta\cdot\sin 2\beta} \quad . \quad (d)$$

which, for the quadrant-shaped inflow zone $\beta=\pi/2$, reduces to

$$\frac{p_2 r^2}{\eta q}=-2\sin 2\theta \quad . \quad . \quad . \quad . \quad (e)$$

so that the average value amounts to

$$\frac{\bar{p}_2 r^2}{\eta q}=-4/\pi \quad . \quad . \quad . \quad . \quad . \quad (f)$$

The solution to problem No. 3 can now be found simply by combining formulæ (a) and (d). The average pressure $\bar{p}$ at any value of β can thus be assessed, and in the particular example $\beta=\pi/2$ it amounts to

$$\bar{p}=\bar{p}_1+\bar{p}_2=\frac{4}{\pi}\cdot\frac{\eta}{r}\cdot\left[\frac{2}{\pi-2}\cdot U-\frac{q}{r}\right] \quad . \quad (g)$$

Adhering essentially to the procedure in the paper for determining pressure p_i at the inlet to the parallel film, and confining ourselves to cases representative of lubrication practice, i.e. to cases where the thickness/length ratio, h/b, of the film is very small, it is found that

$$\bar{p}_i=\frac{4}{\pi}\cdot\left(\frac{2}{\pi-2}-\frac{1}{2}\right)\cdot\frac{\eta U}{h} \quad . \quad . \quad . \quad (h)$$

so that, when introducing the average film pressure $P=\frac{1}{2}p_i$ as a criterion of hydrodynamic load-carrying capacity of the parallel film, the final result is

$$h=\frac{1}{\pi}\cdot\left(\frac{4}{\pi-2}-1\right)\cdot\frac{\eta U}{P}=0\cdot79\frac{\eta U}{P} \quad . \quad . \quad (i)$$

This result, which is approximate, in that the foregoing treatment does not exactly reproduce the conditions in the region of the inflow zone close to the inlet of the film, indicates that the order of magnitude of film thickness h given by formula (23), should be about correct, although it may be a little on the high, i.e. optimistic side.

But it remains to be seen whether it is justifiable to base oneself on pure viscous flow, as has been done in both the analysis of the paper and the present one; that is, whether the inertia effects in the inflow zone may be neglected altogether. This question could perhaps best be solved by direct experimentation, including measurements of pressure in the parallel film as depicted by Fig. 3.

H. BLOK
Professor of Mechanical Engineering,
Delft University.
Rijswijk, July 30th.

CONCEPT OF IRRIGATION DIVERSION HEADWORKS

SIR,—I have had some difficulty in following the examples of economic analysis put forward in the article on "Concept of Irrigation Diversion Headworks" in the issue of June 8th.

The author makes the point at the outset that the comparisons should be on the same basis, and if the barrage scheme is assumed to have an infinite life, it should only be compared with the pumping station scheme if the latter is also assumed to be renewed each twenty years in perpetuity, and not for the second life period only. This factor can be introduced in the comparison by capitalising the annual payment, which, if accumulating at compound interest, will amount to

the renewal expense at the end of twenty years, but the payment must be assumed to continue indefinitely, so that the renewal expenses may also be recovered at the end of each subsequent twenty-year period.

The annual payment factor to be used is (*d*) in the author's list, i.e.

$$\frac{r}{(1+r)^n-1}$$

and this capitalised becomes

$$\frac{1}{(1+r)^n-1}$$

which at 6 per cent interest is 0·45298, instead of 0·3118 derived from the P.V. factor (*b*) as used in the example. This amendment alone will considerably change the comparison in favour of a barrage.

The author does not explain why an interest rate of 5 per cent is used in capitalising the annual working expenses, whereas the sinking fund payments accumulate at 6 per cent. The rate used for both sinking fund and capitalisation calculations should be the long-term investment rate current at the time of making the study, which aims at equating both the annual working and financial expenses to current capital payments. The payment representing the sinking fund accumulates annually at compound interest, whilst the payment representing working expenses is such that the latter are equivalent to the simple interest due annually on the former.

In the second example, Q in the formula is presumably the expenditure per feddan per year and not per day, whilst the interest rates r and r_1 should be identical, but almost certainly not 6 per cent as quoted. The long-term investment rate in the early 'thirties was only about half this value and the correct current value for any particular study should always be ascertained.

Restating the formula to allow for renewal in perpetuity,

$$x\left[P\left(1+\frac{1}{(1+r)^n-1}\right)+\frac{Q}{r}\right]=A,$$

and the value of x becomes 85,708, with $r=6$ per cent and 50,713 with $r=3$ per cent. These results demonstrate the great effect a change of interest rate will have on the comparative economics of schemes involving plant of different life characteristics. A reduction in interest rate will always favour the long-lived plant and vice versa.

N. V. KNIGHT

Chesham Bois,
Bucks,
July 26th.

AEROTHERMOPRESSOR

SIR,—Allow me to say that I was very much interested to learn from the article, "The Aerothermopressor," published in THE ENGINEER of May 18, 1956, how gas turbine performance and characteristics can be improved by means of this device.

Struggling, however, with the intricacies of the underlying theory, as given on page 517, and following carefully the steps the author has taken in deriving the criterion for a rise in stagnation pressure, I find that this Equation (7) should read :

$$\frac{h_0-h_e}{c_pT_0}-\frac{1}{1+\frac{k-1}{2}M^2}\left(\frac{W}{W_e}-1\right)>2.$$

It seems to me that here is an error in printing, but I may be wrong. Besides, has not the factor

$$\frac{1}{1+\frac{k-1}{2}M^2}$$

been omitted in the last terms in the brackets of Equations (3) and (6), dW/W and $(1-W/W_e)$, respectively ?

DR.-ING. M. J. GERCKE

Dusseldorf,
August 7th

Literature

Automatic Digital Calculators. Second edition. By A. D. BOOTH and K. H. V. BOOTH. Butterworth's Scientific Publications, 88, Kingsway, London, W.C.2. Price 32s.

THIS book divides naturally into three main parts, the first historical, the second digital calculating machine design and the component parts, and the third the coding or language for instructing machines. The appearance of the second edition is very timely, as the components and controls designed for these calculators are likely to form the programme and control element in "Automation"—the subject of investigation and comment by such varied bodies as the International Labour Office, Trades Union Congress and *Punch*.

The growth of digital calculating for both business accounting and for scientific work since the first edition came out is immense. While the first edition was well-referenced, the number of the new references to matter published between the two editions and added in the second edition equal the total of those in the first edition. These references to English, French and American literature are particularly rich in English notes giving notice of papers easily overlooked, such as London M.Sc. thesis papers. These references are very valuable in following up a specific subject and of use to those concerned with patents in this field. A trifling, but irritating, omission is the lack of the month in the references to "Electronics," an uncorrected hangover from the first edition.

The great experience of the authors in design and use of digital computers led to a very concise analysis of components and a wise selection of those to be described initially, with the result that the new techniques have fallen into places within the original framework as if prepared for them, and in no way spoil the continuity. The main points added in this second edition are in relation to components for storage and for improved programming. Amongst the former are magnetic core matrices, Ramey amplifiers, ferro-resonant flip-flops, capacitor stores and transistor circuits. Amongst the latter are the iteration counters for counting and controlling the number of times a part of a programme is repeated and the "B Box" register for progressively amending instructions, e.g. the addresses of instructions, where the same group of instructions are repeatedly required. The use of the "B Box" and iteration counter are also shown in the examples given of machine coding. The new worker in this field to whom this work is addressed would do well to appreciate that the drawings and illustrations are an essential part of the text and require careful scrutiny if the text is to be readily followed. It is this technique of not describing what is to be seen in the drawings which has made possible the condensation of so much material into the limits of 250-odd pages.

The book does not purport to describe specifically any of the computers now available commercially, but it is fair to say that all the main features of these have been successfully covered. This is no mean feat in view of their immense variety, and does give the new worker a broad viewpoint. The book has already become a recognised handbook on its subject and the second edition, by virtue of being up-to-date in a very rapidly developing field, can only add to its laurels. It is highly commended.

Geoelektrische Bestimmung von Schichtgrenzen eines tertiären Plateaus mit Quartärbedeckung. By MAX WEBER. MITTEILUNGEN aus dem Institut für Geophysik, No. 27. Eidgenössische Technische Hochschule, Institut für Geophysik, Leonhardstrasse 33, Zürich, 6.

THE present paper deals with geo-electrical measurements carried out on the Stadlerberg mountain, in the Canton of Zürich, with a view to determining the boundary between tertiary (molasse) and quaternary sediments (gravels, moraines). In the first two sections the standard d.c. methods are described. Special adaptations of these methods were employed and are discussed in the third section. The remainder of the paper is devoted to a description of the site, and to details of the working which led to data concerning the specific electric resistivity of the rocks, determination of the thickness of the moraines, and a determination of the former surface of the molasse now overlaid by quaternary gravel.

The Science and Practice of Welding. Fourth edition. By A. C. DAVIS, B.Sc., A.M.I.E.E. Cambridge University Press, 200, Euston Road, London, N.W.1. Price 18s.

IN the twelve years which have passed since the last edition of this book was published a number of new processes have been introduced into commercial welding and cutting practice, and, in addition to an extensive revision, the new edition has been extended to cover these new processes. As before, the book deals in some detail with the basic theory of welding processes and the equipment used. New sections cover argon arc, submerged arc, firecracker and twin arc welding ; flame gauging, powder injection and oxy-arc cutting ; aluminium brazing ; the welding of aluminium bronze and modern Elektron alloys. In addition to providing a handy source of reference for practical welders, this is a useful, up-to-date textbook for students of welding.

Books Received

Theory and Practice of Lubrication for Engineers. By Dudley D. Fuller. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 84s.

The Festiniog Railway. Vol. I, 1800–1889. By J. I. C. Boyd. The Oakwood Press, Bucklands Tandridge Lane, Lingfield, Surrey. Price 24s. 6d.

Resistance of Materials. Fourth edition. By F. B. Seely and J. O. Smith. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 52s.

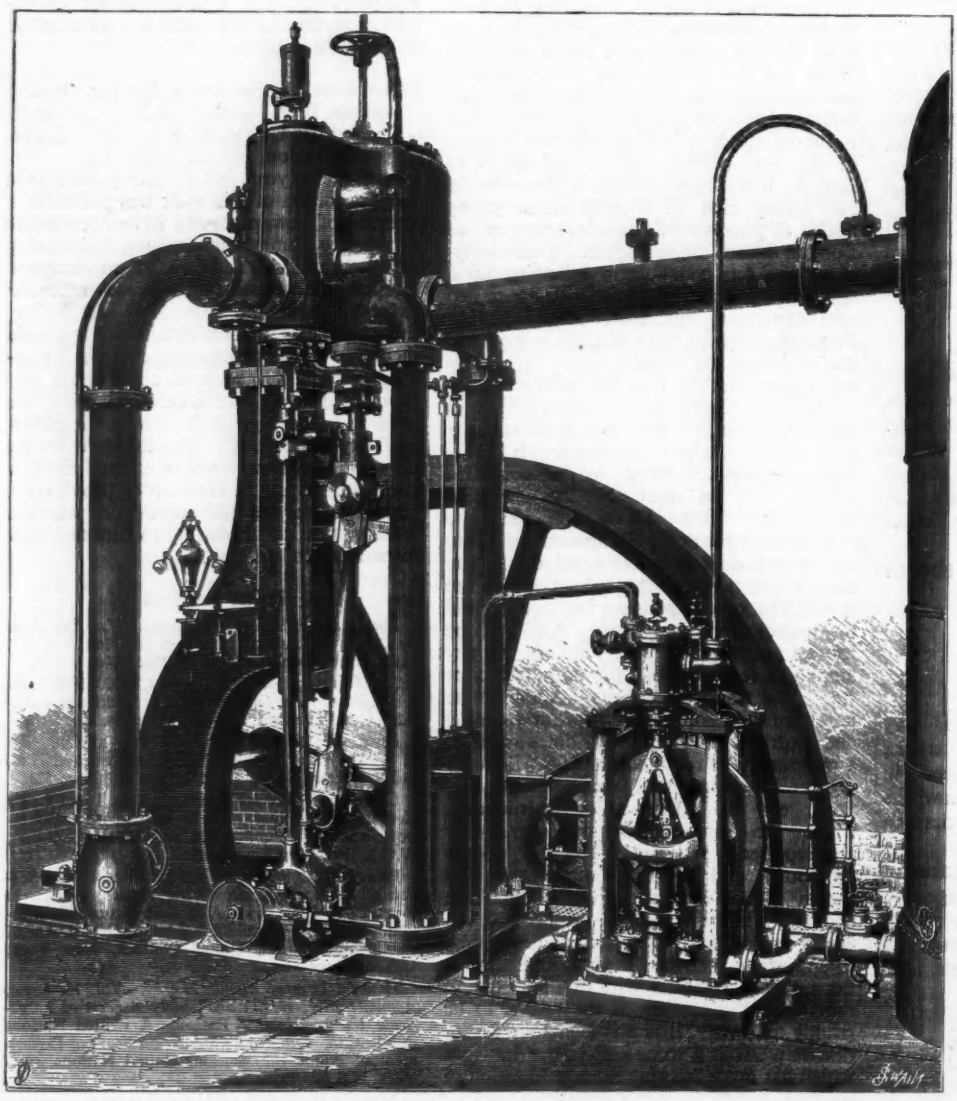
Chemical Engineering Practice. Vols. 1 and 2. By Herbert W. Cremer and Trefor Davies. Butterworth's Scientific Publications, 88, Kingsway, London, W.C.2. Price 95s. per volume.

Peaceful Uses of Atomic Energy. Vol. 15, *Application of Radioactive Isotopes and Fission Products in Research and Industry.* A United Nations Publication. Sales and Circulation Section, Department of Public Information, United Nations, New York, U.S.A. Price 54s.

Peaceful Uses of Atomic Energy. Vol. 13, *Legal, Administrative, Health and Safety Aspects of Large-Scale Use of Nuclear Energy.* A United Nations Publication. Sales and Circulation Section, Department of Public Information, United Nations, New York, U.S.A. Price 50s.

ENGRAVINGS OF 1874

In the latter half of last century, developments in the equipment required for steam cultivation were regularly exhibited at the Royal Agricultural Society's shows. This engraving (right), reproduced from our issue of July 17, 1874, illustrates a "double gear ploughing windlass," introduced by James and Frederick Howard, of Bedford. This equipment was displayed at the Royal Show at Bedford. About it we said: "It is well known that this firm make a ploughing engine in which all the machinery is detached from the boiler, the cylinder being fixed inside the foot-plate guard. It is at any time easy by taking out a few bolts to detach the boiler complete from the whole of the engine and ploughing gear. The winding drums are set vertically at the back of the foot-plate and are driven by gearing."



In a "letter to the Editor," published in our issue of October 23, 1874, some particulars were given of the "Stereopyre," illustrated in the engraving below. It consisted of "a circular fire-grate, made of an interior cylinder of iron, and surrounded with a balustrade of hollow ceramic cylinders arranged in close order, but leaving intervals through which the iron shell may radiate red heat while the balusters radiate invisible rays."

The rolling mill engine at the Darlington Ironworks, illustrated in the left-hand engraving, was described in our issue of September 11, 1874. The engine, which was built to drive a 20in rail mill train, had a cylinder diameter of 42in, with a stroke of 40in; the average speed was about 100 r.p.m. Our description adds: "the fly-wheel is about 20 tons in weight, and the rim cast in one piece, and was turned up on the exterior surface after the engine was erected, thereby enabling the engine to run with more than usual steadiness at an exceptionally high velocity."

New Turbine Steamers for Heysham-Belfast Service

By G. W. TRIPP, O.B.E., F.C.G.I., M.I.C.E.

CONSIDERABLE interest has always been shown in the vessels plying between Great Britain and Northern Ireland, where services have been maintained for upwards of a century, first by steamers owned by private companies and later by those the property of railways. In 1870 an Act of Parliament gave powers to two railways, the London and North Western and the Lancashire and Yorkshire, though competitors in several fields, jointly to operate steamers between Fleetwood and Belfast. The first vessel to be built for the railways was the iron paddle steamer "Princess of Wales," which appeared in 1870 and had a length of 260ft and tonnage of 960 gross. From that time steamers increased in size until in 1892 the long series of "Dukes" began definitely to be attached to this route, although it should be mentioned that a lone "Duke of Connaught" was built as long ago as 1875.

Between 1892 and 1909 no less than eight "Dukes" (Fig. 1) went into service, the first six being twin-screw steamers driven by reciprocating engines, and the last two being triple-screw with direct drive from steam turbines. These vessels had an average length of 316·2ft and average tonnage of 1787 gross. In 1904 the Midland Railway entered into competition by opening a service between the new port of Heysham and Belfast, for which were built four modern steamers,two driven by reciprocating engines and two by turbines, so that the relative performances of the two kinds might be observed.

On the grouping of the railways both services came into the hands of the London Midland and Scottish Railway, which decided to concentrate on Heysham and abandon the old-established Fleetwood route. This led to the disposal of considerable redundant tonnage, most of which found ready service elsewhere, on privately operated cross-channel services.

In 1928 three new "Dukes" entered the service, all from the yard of William Denny and Bros., Dumbarton, these being considerably larger than their predecessors, "Duke of Argyll," "Duke of Lancaster" (Fig. 2), and "Duke of Rothesay." These steamers had the following principal dimensions: length, 349ft; breadth, 53·1ft, depth, 18·5ft; tonnage, 3606 gross. They were driven by four steam turbines operating twin screws through single reduction gearing. They soon came into favour with the public, and have enjoyed long lives for cross-channel craft. Seven years later Harland and Wolff, Ltd., Belfast, built the "Duke of York," in which the second class accommodation was of a very high order. She was transferred to the Harwich-Hook of Holland service to help overcome war losses, and made history by surviving after being cut in two. The rebuilding was described in some detail in these pages.*

It may be remembered that in 1939 an order was placed for two large geared turbine steamers for the Holyhead-Dun Laoghaire sailings, but when the war came the order was cancelled, and much to the surprise of many when the order was placed for new vessels in 1946 it was for two large twin-screw motor ships, "Hibernia" and "Cambria" being among the largest British cross-channel packets.† Accordingly when it was decided that the time had arrived for new tonnage for the Heysham-Belfast service, it was with much interest that it was learned that British Railways was reverting to the geared turbine steamer. Three new steamers were ordered and it was decided that they should be "Dukes," the names selected being "Duke of Lancaster" (Fig. 3), "Duke of Argyll," and "Duke of Rothesay," the first two to be built by Harland and Wolff, Ltd., Belfast, and "Duke of Rothesay" by William Denny and Bros., Ltd., Dumbarton. Their principal dimensions are: length overall, 375ft; between perpendiculars, 354ft; breadth moulded, 55ft; depth moulded to main deck, 19ft 6in; tonnage, 5075 gross, thus making them among the largest cross-channel vessels. Their speed of 21 knots is in accordance with modern practice and ample for vessels employed on night sailings. The vessels have a curved plated stem, a modified cruiser stern and bar keel, and are fitted with bow and stern rudders, two tripod masts, and a streamlined funnel so designed as to throw smoke clear of the passengers. The general arrangement of the decks is as follows: a navigating bridge deck joins the forward and astern navigating bridges on which, in addition to the two wheelhouses, are the captain's and officers' quarters, chart room and radio office; below this is the boat deck amidships, with first class accommodation, and on the starboard side engineers' quarters; next comes the promenade "B" deck with forecastle and poop decks with more first class accommodation and lounge; further down the upper "C" deck forward has the first class smokeroom, astern of which is the first class dining saloon seating seventy-six people, and further astern the cook's galley, second class lounge and a cafeteria seating ninety-six people; on the main "D" deck there is further second class accommodation, also the fan room, crew's galley and pantry, a buffet bar and baggage room; finally on the lower deck "E" forward and astern of the engine room and boiler house is more second class accommodation. In all 1800 passengers can be carried, 600 in the first class and 1200 in the second, while there are cabins for 240 passengers in the first and 216 in the second class, the first class including four cabins-de-luxe, each with its own private bathroom and toilet. There are two cargo holds forward and between decks forward and aft for the carriage of general cargo, motor cars and newspapers. Mails and baggage are carried in special compartments aft.

The hull is subdivided by ten watertight bulkheads, the watertight doors being electrically controlled from the navigating bridge. The peaks and double bottom are arranged for the carriage of water ballast, with lubricating oil drain tanks below the turbines. Oil fuel and fresh water are carried in tanks built into the ship's structures, on top of the double bottom. Before leaving the general arrangement it should be mentioned that extensive promenade space has been provided for both classes of passenger, with garden seats fitted along the sides of the deck houses. A full height ship's side screen with fixed and sliding windows has been fitted along the promenade decks to give protection in bad weather. The temperature in the public rooms is controlled by regulating valves in the main trunks, while provision has been made in each cabin for independent temperature regulation by the occupant, the mechanical ventilation is on the "Thermo-Reg" system. A sound reproduction equipment is fitted with speakers in public rooms, on decks and other places so that music or important messages can be broadcast; microphones are fitted in each wheelhouse and also in the first class bureau for this purpose.

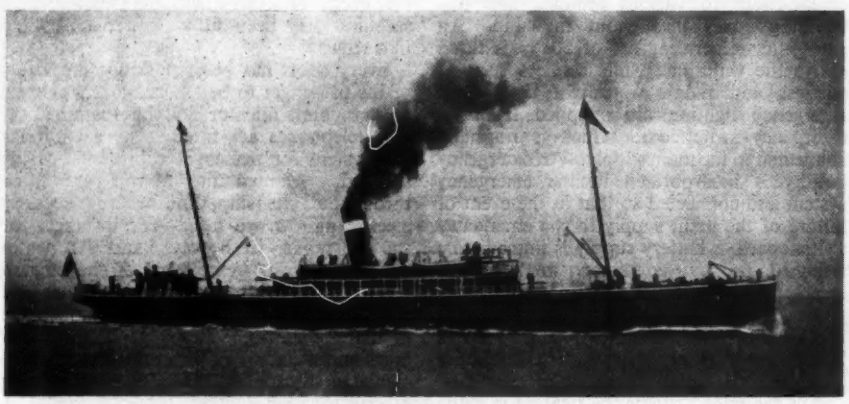


Fig. 1—"Duke of Clarence," 1892

The propelling machinery consists of two sets of turbines and locked train articulated double-reduction gearing, driving twin screws, the complete installation being designed to develop 10,500 s.h.p. at a propeller speed of not more than 225 revolutions per minute. The power units each comprise a single casing all-impulse turbine, incorporating ahead and astern units. The condenser for each unit is of the underslung design with spring supports beneath; the condensers are designed to maintain a vacuum of 28½in. The propellers are solid, with streamline bosses of "Heliston" design. The thrust blocks are each of Michell design, and are incorporated with the gear cases. There are two Babcock and Wilcox boilers, manufactured by the builders, each having integral furnaces and two drums, and fitted with superheater, flue gas air heater, and steam soot blowers. The boilers are arranged to burn oil fuel under open stokehold forced draught, the steam pressure being 350 lb per square inch with a steam temperature of 700 deg. Fah. The Weir closed feed system is installed complete with

* THE ENGINEER, April 23, 1954, Page 601.

† THE ENGINEER, April 22, 1949, Page 432.

all the necessary equipment, including extraction pumps, air ejectors, gland steam condensers, drain cooler, turbo-feed pumps, auxiliary feed pump and primary and secondary feed heaters.

All the auxiliary machinery is electrically driven, apart from the air ejectors, turbo-feed pumps, and main circulating pumps. Three diesel-engine-driven generators supplied by W. H. Allen, Sons and Co., Ltd., Bedford, arranged in the engine-room, and placed alternately with the propelling units, are each capable of giving an output of 240kW at 220V d.c. when running at a speed of 410 r.p.m. The engines are of the four-stroke, trunk piston, airless injection, single-acting type, having six cylinders, 325mm diameter by 370mm stroke, and capable of starting from cold with compressed air at 300 lb per square inch. The two starting air reservoirs are charged by an electric motor-driven compressor, and a small hand-driven compressor provides the air for starting up the emergency diesel generator which is situated outside the engine-room. An engineers' workplace is provided by the stores, fitted with a bench and vices. Electricity is supplied by three diesel generating sets, each 240kW at 220V d.c., and is distributed through a main switchboard in the engine-room to various sections and distributing boxes throughout the ship. An emergency generating set of 50kW is fitted above the waterline, while services such as wireless and radar, watertight doors and emergency lighting are supplied from an emergency switchboard which is normally connected to the main supply. An emergency battery is incorporated in the emergency system and connected so that in the event of failure of the main supply to the emergency switchboard, a battery supply is immediately switched on by contactor to keep the emergency services going until the emergency generator is started up and switched over. In all, eighty electric motors, ranging up to 70 h.p., are fitted, and there are 2000 electric lamps. Berth lights are fitted to each bed, and in the public rooms the lighting is made to harmonise with the decorations.

Among aids to navigation may be mentioned wireless, radar, echo sounder, Decca navigator, direction finder, navigation light indicator, Chernikeef log, all of which are fitted in the forward wheelhouse, while a second radar screen is fitted in the after wheelhouse to be used when the vessel is being navigated from this position. Steering is operated by two steering gears, one in the stern and the other in the bow for use when the ship is going astern and for berthing. "Synchrostep" electric telegraphs are installed for main and emergency engine-room telegraphs, also steering, docking, anchor and bow rudder telegraphs. The ship's whistles are electrically operated. Motor-driven watertight doors are fitted below the water line, these being closed from the bridge in the event of emergency. A Denny-Brown stabiliser has been fitted to reduce rolling in a seaway.

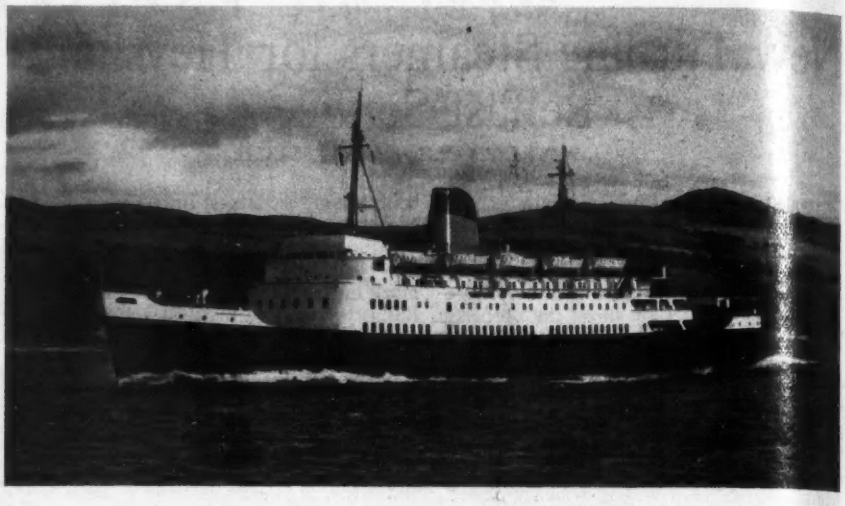


Fig. 3—"Duke of Lancaster," 1956

Every effort has been made for the safety of the passenger to be assured, loudaphones, master communicator and intercommunication telephones are fitted, also a luminous call system for passenger cabin calls to the steward. Manual fire alarms are fitted throughout the ship, and where necesssry electric alarms are fitted—for instance, for the oil tanks, fresh water and salt water systems, steering gear, some of the engine-room pumps, for the most part connected to a control visual and aural electric alarm panel in the engine-room. Each generator has a lamp and aural alarm panel fitted to give the alarm on the failure of its own lubricating oil, fresh water and salt water systems. A combined CO_2 fire-extinguishing and smoke-detecting system has been installed to serve the cargo spaces and stewards' stores, and a "Grinnell" automatic sprinkler fire-extinguishing system is fitted throughout the passenger and crew accommodation. The lifeboat equipment consists of two 24ft motor lifeboats, and eight 24ft hand-propelled Viking lifeboats, all of aluminium alloy, fitted under Welin-MacLachlan gravity davits; buoyant seats and liferafts are also available.

It is a far cry from the graceful little paddle steamer "Princess of Wales" of 1870 to the "Duke of Lancaster" of 1956, but it has been a period of progress in the development of the cross-Channel steamer, so that the second class accommodation to-day is infinitely superior to the first class of those early days; indeed, on boarding the "Duke of Lancaster," the first impression is one of spaciousness and comfort. The "Duke of Lancaster" made her maiden voyage from Heysham to Belfast on Friday, August 24th.

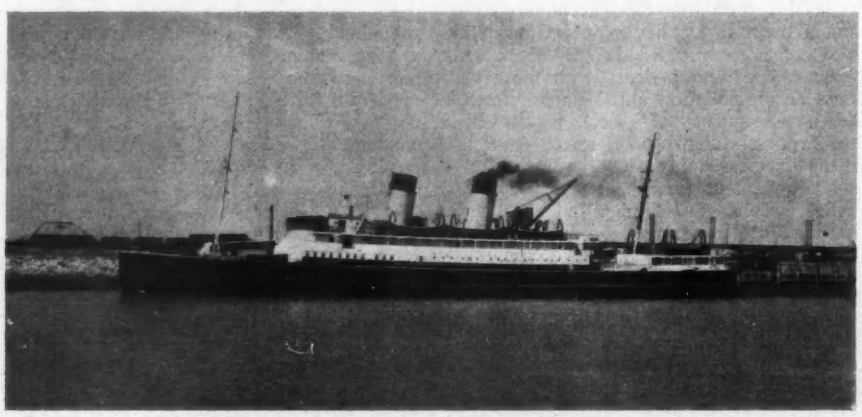


Fig. 2—"Duke of Lancaster," 1928, at Heysham

Continuous Carburising

For case hardening and quenching gears of alloy steel, E.N.V. Engineering Company, Ltd., has recently installed a gas carburising furnace.

Pack carburising and quenching by oil bath or under presses by conventional methods were and still are employed, especially for special gears which require individual treatment. Gas carburisers of the pit type have been used for many years with such good results that it was decided to investigate the possibilities of continuous gas carburising, a development of the batch process, used increasingly in the U.S.A., where experience seemed to indicate that the continuous process was the most satisfactory treatment yet devised for the consistent production of gears. This consideration, added to economic advantages, influenced the decision to install a continuous gas carburising furnace, in the design of which the firm's metallurgists collaborated with the design team of Birlec, Ltd.

Experience has shown that although carburising atmosphere gas can be satisfactorily prepared from town's gas, the composition of gas from the supply mains is liable to considerable variation.

This would have introduced difficulties in obtaining the degree of consistency which was the main objective of the new installation and it was therefore decided to manufacture the furnace atmosphere from propane.

Two storage tanks for liquefied petroleum gas are installed outside the building, and replenished in bulk from road tank wagons. The fuel is piped at a low pressure, about 2 lb per square inch, into three Birlec endothermic generators; one serves the furnace chamber proper, another the lock chambers at each end, and the third is held as a standby.

Town's gas is used to heat the furnace, burning in transverse radiant tubes above and below the workpieces; it was considered at the temperatures involved—characteristically 920 deg. Cent. for carburising—electric elements might require unduly frequent maintenance.

The gears pass through the plant on square trays, for which various high nickel alloys have been employed. These trays run on three parallel tracks, and are moved by pushing the rearmost tray in each track. As can be seen in the illustration, they are loaded three at a time: there are sixty trays in the furnace and a typical

treatment takes thirteen hours, so that a tray is moved every thirteen minutes and loading is required at thirty-nine-minute intervals. Each of the three tracks has a timer which sounds and lights signals when a push is due, and one push button starts an automatic sequence. The water-cooled door separating the charge chamber from the first zone of the furnace chamber opens and the new tray is pushed into the furnace ; the door then closes. The foremost tray will now be opposite the discharge pusher, and will be moved sideways into the discharge vestibule. If the automatic sequence continues, it will then be lowered into a stream of oil, moved back to the discharge position, raised again, and pushed out of the plant ; the vestibule will then be purged. If the work requires to be quenched in a press to control distortion, a switch is selected, and instead of the tray being lowered into the tank it is extracted manually from another door ; the work is then manhandled to the quenching presses.

Three trays of work being loaded into the continuous gas carburising furnace

The heating chamber is divided into four zones, in the first of which the work attains treatment temperature. In the second and third gas circulating fans run to ensure uniform carburising over all surfaces. In the final zone the quenching temperature is achieved, and either heating or cooling can be applied. All zones are automatically regulated by duplicated thermo-couple equipment and Honeywell controllers.

A convenient means of assessing the carburising potential of the atmosphere gas is by measurement of its dew point, and a recording instrument is provided for this purpose, being arranged to operate either on the generator gas or on the furnace atmosphere, which comprises generator gas enriched with propane. To give a case of about 0·8 per cent carbon content, a propane addition of about 1 per cent of the atmosphere gas flow is needed, corresponding to a depression of dew point from 30 deg./40 deg. Cent. as generated, to 10 deg./15 deg. Cent. in the furnace.

A range of case depths between about 0·03in and 0·06in is obtained by variation in the cycle time. For practical purposes, a minimum track cycle time of about twenty-seven minutes is used, corresponding to nine hours' total time for each tray load in the furnace, and under these conditions an output as high as 800 lb per hour is obtainable with a case depth of the order of 0·038in. It is noteworthy that independent cycle timing devices are provided for each of the three furnace tracks so that work may move at a different speed on each track, if required, to produce different case depths.

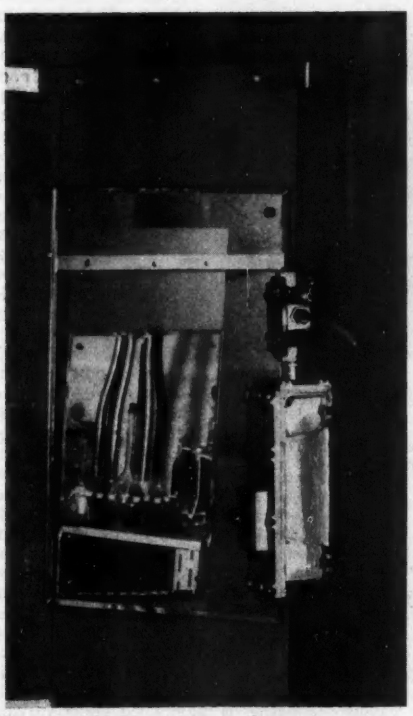
The furnace can be run at full output by only two men, who also operate the washing machine through which the parts pass before entering it in order to avoid contamination of the atmosphere. When press quenching is employed, a third man is desirable.

This installation is the first continuous gas furnace commissioned by Birlec, Ltd., Tyburn Road, Erdington, Birmingham, 24, and is the largest carburising plant to run on propane in this country.

Irradiation Laboratory

THE progress of radiation chemistry has revealed potentialities for greatly modifying the mechanism of polymerisation. Irradiation can cause normal chain polymers, such as polyethylene, to cross-link and acquire effectively infinite molecular weight. Also, compounds which would not normally do so can be caused to polymerise, and "block polymers," including two differing molecules, can be created. An example of such a process is the vulcanisation of rubber without sulphur ; irradiation causes cross-linking directly between carbon atoms without sulphur atoms intervening, and the resulting solid rubber is expected to show markedly better high temperature properties. To investigate these and allied phenomena, at the Dunlop Research Centre at Fort Dunlop, Birmingham, 24, an irradiation laboratory has been built.

The source of radiation selected was radioactive isotopes, in view of their increasingly easy availability. An accelerator may be required, once the direction of research becomes more clearly defined. The source at present in use is cobalt 60 of, originally, 100 curies, but the laboratory is built to accept a source of 1000 curies. The radiation is controlled by withdrawing the source from the working position within a shield of concrete. For this purpose the source is contained in a stainless steel cylinder abour 3in long. running within one of six brass tubes of about 1in bore. In the working condition, the source is at the bottom end, seen in the accompanying illustration, of its tube ; the offset end of each tube can be rotated, so that the six ends can be grouped together or spread out. Above the table seen, the tubes turn into the horizontal direction and lead into a mass of concrete, in the middle of which the sources are stored when radiation is not required. The sources are propelled to and fro by Teleflex cable ; the loads involved are so light that the cable can be allowed to run freely in the large brass tube. The bottom end of a charged tube has a blank silver-soldered on it, so that if the cable does break in the working position the source cannot roll at random about the irradiation space.



Source tubes and samples, seen by means of two mirrors and through a barred gate

The working space is approached through a labyrinth of concrete blocks, guarded by a barred gate. A single key is provided for the operator, which is trapped in the gate mechanism unless the gate is shut and in the source moving mechanism unless the source is withdrawn. In addition, a Geiger counter allows him to check the level of radiation in the working space before entering, and he carries with him a portable dosimeter. In the working chamber there is a switch which can lock the gate open, so that anyone inside can safeguard himself from being locked in ; a second gate at the inner end of the labyrinth is being erected so that the operator must visit the chamber before locking up and driving in the sources.

The samples being irradiated can be observed by two mirrors at the corners of the labyrinth, telescopes being provided for this purpose. Pipes run through the concrete to lead electric cables or other services to the working space. The source itself is at the end of a wire trace about 1ft long, so that it can remain inside a leaden casket while it is connected to, or disconnected from, the driving cable.

Wire Rope Works

FOR more than fifty years the firm of William Cooke and Co., Ltd., has been manufacturing wire ropes at its works in Tinsley, Sheffield, and it recently opened a new works at Rotherham for the production of ropes from ¾in circumference up to 2in diameter. This new factory, now building up to full production as new hands are trained, will enable a considerable increase to be made in the firm's output. It has a main shop some 320ft long by 130ft wide, in which the plant has been arranged for a straight production flow from wire stores at one end to despatch stores at the other end. The principal rope-making machines at present installed include sixteen high-speed stranders and six high-speed closers and there is ample room for installing further plant when required.

Under the production programme all wire supplied to the factory is stored on racks against one end wall, and no coil is released for rope-making purposes until it has been tested and approved. The coils of wire are then passed on to bobbin winding machines which supply the stranders feeding the closing machines on which the ropes are completed and wound on to drums. The drums of wire rope are transferred to storage racks by fork lift trucks. Before any completed drum of rope is accepted for the finished stores it has to pass the specified usage tests, and a sample is cut off for testing in a 100-ton capacity machine housed in one corner of the shop. At the rear of the drum storage lines there is a splicing and ending section on which the required lengths of ropes are cut off and fitted with the eyes or hooks specified by the purchasers. To facilitate the handling of the heavy bobbins of wire or rope strands between the machines a system of overhead rails carrying pulley blocks has been installed over the whole area of the machine lines.

A wing built along the whole length of one side of the main shop accommodates a research department, tool room and maintenance shop.

High-Energy Spark Ignition Equipment for Oil Burners

A HIGH-ENERGY spark ignition equipment for burners using high-viscosity oils has been introduced by Foster Transformers, Ltd., South Wimbledon, London, S.W.19. The equipment is available in two forms. Type "A" produces a maximum energy of 1 joule and is designed for igniting oils with viscosities of more than 1 second Redwood. Type "B" produces a maximum energy of 8 joules and is designed for igniting oils with viscosities of 4000 to 10,000 seconds Redwood. The energy available at the spark

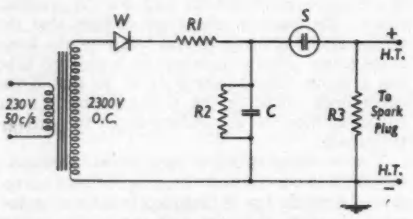


Fig. 1—Circuit of high-energy spark ignition equipment for oils with viscosities above 1000 seconds Redwood

itself is stated to be 50 per cent, or more, of the values given above.

The spark plug used in the high-energy system is one that was developed primarily for the ignition of atomised fuel in the combustion chambers of gas turbine engines in which conditions of gas pressure, altitude and temperature vary widely. The spark plug electrodes consist of a rod and cylinder concentrically mounted and insulated from each other; the ends of the electrodes and the insulation are flush and the insulation at this point carries a surface coat of semi-conducting material. When a voltage is applied to the electrodes a current flows in the semi-conductor and, since the material is not homogeneous the current tends to concentrate into a channel of minimum resistance. This channel heats up and increases the current, thus further increasing the temperature. This cumulative action causes a filament to be formed, the temperature of which is high enough to cause thermal ionisation, resulting in an arc between the electrodes. Depending on the initial voltage applied, this action may take as little time as 1 microsecond.

Two advantages of this form of spark are that since the spark is initiated within the semi-conductor its formation is not prevented by corrosion of the electrode, and that, as the voltage required is only 2000V, the cabling is cheaper than that normally required in high-voltage ignition practice.

The electrical circuit required to supply the spark plug is shown in Fig. 1, from which it can be seen that each high-energy equipment consists of an isolating transformer supplying approximately 2300V to a half-wave metal rectifier *W*, limiting resistance *R*1 and storage condenser *C*. Leak resistance *R*2 prevents a dangerous voltage remaining on *C* when the equipment is de-energised. The condenser *C* is connected to the spark plug via spark gap *S*, and by-pass resistor *R*3 provides closer coupling of *C* to *S*. The spark gap *S* is designed to break down when the condenser *C* reaches a potential of 2000V at which time this voltage is applied to the spark plug. The condenser *C* therefore discharges into the spark plug, causing an arc as described.

The two forms of the high-energy ignition units "A" and "B" are illustrated in Fig. 2, and the main particulars are given here.

Type	Condenser *C*	Energy output	Spark gap	Sparking interval
"A"	0·5μfd	1 joule	Tungsten points ...	0·75 sec
"B"	4·0μfd	8 joules	Sealed gap, hydrogen filled	1·0 sec

The ignition units are designed for intermittent duty: that is, it is expected that a maximum of five sparks would be necessary to ignite the oil, after which time the oil jet would remain ignited. The rated duty cycle is 5 seconds "on," 10 minutes off. The dimensions of both units are 8in by 5¼in by 5in deep. The container is designed for panel mounting with mains cable entry and outgoing cable connections at the rear.

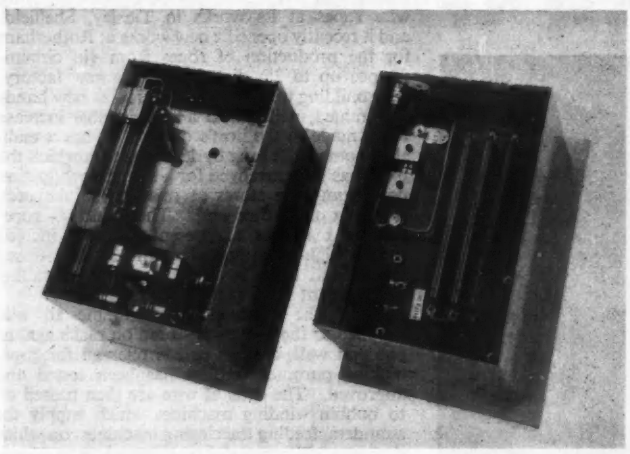


Fig. 2—High-energy ignition equipments for high-viscosity oils. Model B (left) has a hydrogen-filled spark gap and an energy output of 8 joules. Model A (right) has tungsten points and an output of 1 joule

Cooling System for Weaving Shed

THE automatic loom mill weaving shed recently completed at Blackburn, Lancashire, for Thomas Longworth (Sales), Ltd., has been built for the production of man-made fibres, including Nylon, Terylene and Rayon. Part of the equipment installed is a Thermotank heating and adiabatic cooling system, by which, under warm outside conditions, the air is saturated adiabatically so that the dry bulb temperature of the air leaving the washer is approximately the same as its wet bulb temperature when it entered the washer.

The volume of the space served is 233,000 cubic feet and the installation, which is capable of supplying 36,000 cubic feet of conditioned air per minute, is designed to maintain 68 deg. Fah. dry bulb in winter, when the outside temperature is 25 deg. Fah. dry bulb. In the summer internal conditions will be controlled at 75 deg. Fah. dry bulb, until the ambient wet bulb temperature of the air rises above 60 deg. Fah., at which point the internal temperature will rise with the increase in ambient conditions. However, under these conditions, the relative humidity of the inside air will be maintained at a constant 60 per cent.

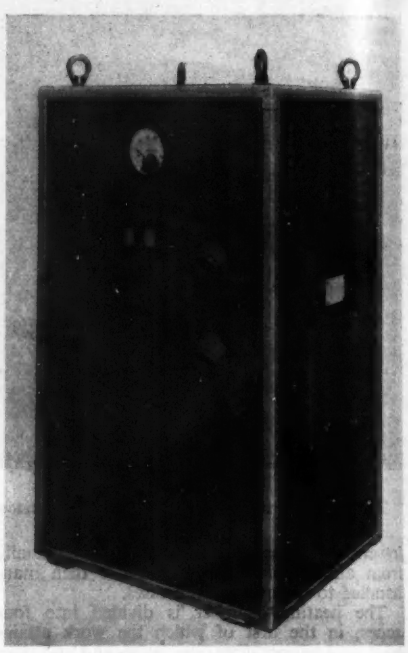
The air supply is drawn into the plant room and passed through gauze filters, which remove any yarn "fly," before passing through a pre-heater, air-washer and after-heater, where it is treated and then discharged by the supply fan into the duct system. Three modulating controllers, a dew point thermostat, a dry bulb thermostat and a "Humidistat" maintain the internal condition. The dew point thermostat, placed at the air inlet side of the air washer, controls, in sequence, the steam valve at the pre-heater and the movement of the fresh and return air dampers so that the desired condition of the air leaving the washer is maintained under varying ambient conditions. The dry bulb thermostat is in the weaving shed and controls the temperature of the space by operating a steam valve at the after-heater. Also in the weaving shed is the "Humidistat" which operates the volume control damper at the fan discharge to reduce the air supply if the relative humidity of the space rises.

To prevent the infiltration of outside air through windows and doors, the weaving shed is slightly pressurised and non-return valves are fitted in one wall to allow excess air to escape. Thermal insulation of the weaving shed is provided for by using cavity walls in its construction and the fitting of a false under-hung ceiling. Both the ceiling and the air ducts above it are insulated with a glass wool blanket.

Rectifier Arc-Welding Set

WE illustrate a rectifier-fed arc-welding set which is designed to take a three-phase balanced load from the mains at an average power factor of 0·7 over a range of one-quarter load to full load (100A to 450A). It is manufactured by Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester, 17. The efficiency of the equipment is given as 71 per cent at full load and 66 per cent at half load.

One advantage claimed for the equipment is the high initial current surge. In addition, open circuit recovery voltage on the instant of breaking a short circuit is about 15 to 20 per cent higher than that of the m.g. set.



Rectifier arc-welding set with a range of 100A to 450A and a full load efficiency of 71 per cent at 0·7 power factor

In the new rectifier set the welding current adjuster gives stepless adjustment over the whole current range. It comprises a wire-wound potentiometer controlling the d.c. current in the transductor circuit, completely enclosed in a sheet metal box with sockets engaging into the front face of the set. This arrangement enables the control to be taken to the job by the operator; 20ft of cable is supplied for this purpose. The voltage on this control circuit is about 25V. An ammeter is provided.

The only moving part which requires servicing is the air circulating fan. This draws air in at the top of the set and expels it through the bottom louvres. A three-pole rotary switch on the front panel isolates the supply to the main transformer. The welding pliers lead and the earth return lead from the work are fitted with standard 450A insulated sockets as used on the a.c. multi-operator sets.

The standard range of 100A to 450A can be changed to 30A to 300A by altering the transductor connections inside the set. The main dimensions of the equipment are: overall height, 4ft; overall width, 2ft 4in; overall depth, 2ft 3in; approximate weight, 1100 lb.

Industrial and Labour Notes

Report on the Steel Industry's Dispute

The report has now been published of the Court of Inquiry, set up by the Minister of Labour on July 13th, to examine the dispute concerning maintenance workers in the iron and steel industry. The bodies involved in the dispute were the Iron and Steel Trades Employers' Association, representing thirty-one companies in the industry, and the National Joint Trade Unions' Craftsmen's Iron and Steel Committee, representing about 12,000 skilled craftsmen employed on maintenance work. On April 26th, the craft unions represented by the committee imposed a ban on overtime in support of a wage claim, and on July 4th they gave notice of a strike which was timed to start on July 14th. Strike action was, however, deferred when the Court of Inquiry was set up, and, subsequently, at the Court's suggestion, the ban on overtime was lifted.

In surveying the history of the dispute, the report mentions a national procedure agreement, providing, among other matters, for the automatic reference to arbitration of unresolved disputes. The craft unions were anxious to have this clause amended so that arbitration became optional, but the negotiations on this point were not successful and the unions gave notice of the termination of the procedure agreement. Meanwhile, the unions had put forward a claim for a substantial wage increase, and at the beginning of March, the employers made an offer of 10s. a normal week, an amount which had been accepted by the production workers. The craft unions rejected this, on the grounds that their members should have a differential above the increase granted to the production workers. The unions also rejected a suggestion that the matter should go to arbitration.

Sir John Stewart presided over the Court of Inquiry. In apportioning responsibility for the disturbance of iron and steel production which occurred as a result of the dispute, the Court expresses the view that the employers should have made "more earnest efforts to find a formula which would have helped to remove the craft unions' doubts about arbitration." At the same time, the Court blames the unions for ignoring an undertaking to resort to negotiation at district level in the event of the national procedure agreement lapsing. This action is described in the report as the cause of all the trouble which culminated in a precipitate and unconstitutional embargo on overtime. About the unions' demand for a change in the wage structure, the report says that "this appears to be an entirely new feature." The Court's opinion is that, pending the working out of a comprehensive scheme for discussion with the Iron and Steel Trades Employers' Association, the craft unions cannot evade the responsibility of accepting forthwith the offer of the 10s. a week increase made last March. It is emphasised that negotiations for a new claim, if and when it comes to be formulated in detail, should be referred to the machinery which has already been established for the craft unions in the industry. But, it is suggested that, in case negotiations break down, a "quite new form of arbitration devised to meet the special needs of the industry should be incorporated in the national procedure agreement."

Iron Castings Production

A statement by the Iron and Steel Board shows that, in the second quarter of this year, production of iron castings in the United Kingdom amounted to 1,022,040 tons, compared with 996,600 tons in the corresponding period of last year. The Council of Ironfoundry Associations has pointed out that over the first six months of this year, the output of iron castings was 3 per cent higher than in the first half of 1955.

The Council has also explained that in the second quarter of this year the output of ingot moulds reached a record figure of 113,960 tons. The second quarter's production of automobile castings, however, at 124,840 tons, was 8 per cent below the figure for the comparable period of last year. The output of general engineering castings in the second quarter, at 378,850 tons, was a little below the first quarter's total, but was nearly 3 per cent above the output recorded for the second quarter of 1955.

During the second quarter of this year, the Council states, the ironfounding industry's consumption of its principal raw materials was: pig iron, 627,300 tons, and scrap, 804,100 tons. On June 30th last, the number of people employed in the ironfounding industry was 143,343, compared with 145,444 at the end of the preceding quarter.

Fire Alarms in Factories

During a debate in the House of Commons a few months ago, it was suggested that between 50 and 70 per cent of factories governed by the Factories Act had no fire alarms. It was then emphasised that the Factories Act requires that a fire alarm must be installed in any factory employing more than twenty workers, or where explosives and highly inflammable materials are stored or used.

The Ministry of Labour has circulated leaflets to all such factories to guide them in complying with the Act. In the belief that factory managements may like to have fuller information, the Fire Protection Association has prepared a leaflet dealing briefly with the kinds of fire alarms that are available. For general guidance on fire protection for industrial managements, the Association has issued booklets and leaflets on fire-extinguishing equipment, building construction to limit fire spread, and fire protection in offices and industrial and storage buildings. All these are available free of charge on application to the Association at 15, Queen Street, London, E.C.4.

Overseas Trade

The value of United Kingdom goods and manufactures exported in July was £266,200,000, which, although below the record figures reached in May and June, was about the same as the monthly average for the first half of the year. The July export figure is usually a good one, but this year the month contained only twenty-five working days, compared with twenty-six in May and June. Imports into this country during July were valued at £320,100,000, which was 3 per cent below the average for the first six months of this year, and 1 per cent below the monthly average for the whole of 1955. The Board of Trade says that the cumulative total of imports for the first seven months of this year now shows an increase of only 2½ per cent over the corresponding period of 1955. Re-exports in July were valued at £9,800,000, so that at the end of the month the visible trade deficit stood at £44,100,000.

The commodity pattern of exports in July was much the same as in the earlier months of this year. Engineering products, valued at £109,500,000, were on a level with the average of the first six months, though exports of metals, valued at £38,000,000, were 4 per cent above the average for the first half of the year. In the various divisions of engineering exports there was little change. Exports of machinery "other than electric" were valued at £43,000,000 in July, and thus showed a little reduction compared with earlier months; the shipments to India and Finland were somewhat reduced, but there were increases to Australia and Canada. Exports of electrical machinery and apparatus, valued at £18,500,000, were virtually unchanged, and aircraft exports continued at about the same level as in the earlier months of the year, namely, £6,500,000. Exports of cars and chassis increased in July to a value of over £11,000,000, and thereby continued the improvement shown in the second quarter of the year; they were in fact about 13½ per cent above the January-June average. Car exports to New Zealand and exports of chassis to Australia increased in July, but car exports to Canada declined. Exports of commercial vehicles and chassis, at a value of £7,500,000, were 8 per cent below the average for the first half of the year. Exports of railway vehicles continued at a relatively high rate in July. On the other hand, exports of ships and boats, after the high figures recorded for May and June, fell to under £7,500,000 in July, though they were still only 6 per cent below the January-June average and were well above last year's monthly rate. The rise in the export of metals was accounted for by an increase of 25 per cent in shipments of non-ferrous base metals, which approached a value of £10,000,000 in July. Most of the increase occurred in copper and copper alloys. The actual quantity of these metals shipped was 58 per cent above the January-June average, but, with lower prices, the value was 41 per cent up. Most of the increase, the Board of Trade says, was taken by Russia and Western Germany. Exports of iron and steel, however, declined in July, by 4½ per cent, to a value of rather less than £14,000,000.

Industry's Labour Costs

In the August issue of *Bulletin for Industry*, which is prepared by the Treasury, the rising costs of industrial production are analysed, in the light of statistics included in the annual report on "National Income and Expenditure." Dealing with labour costs, the *Bulletin* gives the following index numbers (1948=100) for the various industrial classifications in 1955:—manufacturing industry, 177; mining and quarrying, 149; building and contracting, 165; electricity, gas and water, 182.

The *Bulletin* says that these indices "must be interpreted with caution." They are based on a complex range of National Income data, and are necessarily subject to substantial and varying degrees of error. But it is pointed out that in 1954 wages and salaries in industry generally rose only slightly faster than output, so that wages and salaries per unit of output rose 1 per cent. Last year, however, wages and salaries rose twice as fast as output, and, per unit of output, they went up 4 per cent. The *Bulletin* then observes that when this rise in labour costs in industry is assessed in relation to the general economic situation, there are two points which stand out. First, it is suggested, there is generally more scope in industry, especially manufacturing industry, for raising productivity than there is in the rest of the economy. This makes it easier for industry to offset, or more than offset, increased wages and salaries by increased output, thereby stabilising or reducing labour costs. Elsewhere in the economy, the *Bulletin* adds, it is more difficult to increase productivity than in industry. Consequently, if labour costs per unit of output are to stay stable for the whole economy, labour costs per unit of output in industry need to fall.

The second point made in the survey is that, apparently, there has been no comparable increase in labour costs in Western Germany. It has been suggested recently that between 1950 and 1955 labour costs per unit of output in manufacturing industry rose by more than 25 per cent in the United Kingdom and by only about 2 per cent in Western Germany.

Funds for the Iron and Steel Board

The Board of Trade has made an order, under the Iron and Steel Act, 1953, confirming a revised scheme for the provision of funds for the Iron and Steel Board. Under the Act, funds necessary to meet the expenditure of the Iron and Steel Board are provided by periodical contributions from iron and steel producers. Originally, these contributions took the form of a levy on steel ingots of 4½d. a ton on each ingot over 1 ton in weight, and 4d. a ton for pig iron other than that used in steel production. The new scheme, which has now been approved by the Board of Trade, reduces these rates to 3d. and 2½d. a ton respectively. The order, authorising the scheme, will take effect from September 2nd.

Italian Oil and Gas Industry

By V. S. SWAMINATHAN, M.A., M.Sc. (Lond.)

No. I

Since the war there has been a rapid expansion in the Italian oil and gas industry, a natural gas grid has been constructed in the Po valley, oil fields have been opened up and refineries built at several places, including Genoa, Venice, Naples and Bari. The natural gas industry is described in this article (No. I) and the oil industry will be the subject of a concluding article, No. II.

ITALY'S economic strength is conditioned by the availability of cheap power. Barely a decade ago the country seemed irremediably handicapped, good quality coal was lacking, and there was also a lack in liquid and gaseous hydrocarbon fuels. As to her water power resources, their exploitation by that time was deemed to be so far advanced that no further important developments could be envisaged. Moreover, the harnessing of natural steam for generating thermal power, started at Larderello in Pisa, did not appear susceptible of any substantial increase. Only faith in the radical changes to be brought about by the use of nuclear energy gave Italian scientists and technicians a more promising prospect for the economic future of the nation in the immediate post-war period. Fortunately for Italy, there has been a "silent" revolution in the field of sources of energy since then. This can be stated briefly as follows. Domestic consumption of energy in 1954 was approximately 42,000,000 metric tons of coal equivalent, and of this total solid fuels supplied 26 per cent, liquid fuels 32 per cent, and natural gas 11 per cent, the comparative figures for 1938 being 47, 12, and less than 1 per cent respectively.

Turning first to Italian enterprise in the Larderello region, some 20 miles south-east of Leghorn, here the natural steam vents are employed to power eight electricity generating plants, including a mobile installation, with a total output capacity of 265,500kW. In 1953 power production amounted to 1775 million kWh, most of which was sold to the Italian State Railways and the rest to private distributing companies. This steam is also used as a raw material for the extraction of boric acid, borax and ammonium bicarbonate. All production is in the hands of the Larderello Company, which is a private concern. The direct mechanical application of natural steam from this region was successfully accomplished just over fifty years ago, when a 35 h.p. to 40 h.p. piston engine operating a dynamo produced electricity for the entire plant, including the drilling rig, while Larderello No. 3 power station, the latest installation, commissioned in 1950, has an output of 118,000kW. Another recent innovation is the development of a "packaged" direct application turbo-electric set with a 3000kW output at 4·5kV, with a forced-cooled transformer. This set is designed for rapid installation at any site, where natural steam is found, to utilise power that might otherwise be wasted for the period of two years or more required for the construction and testing of a full-scale station.

To make up for lack of private enterprise in the field of prospecting for hydrocarbon fuels, a State organisation, Aziende Generale Italian Petroli (A.G.I.P.) was set up in 1926. Soon after the second world war it located a large methane gas field at Caviaga, some 20 miles south-east of Milan, and in the following years discovered a whole series of natural gas fields in the Po Valley region, some being more important than that at Caviaga, such as Ripalta and Cortemaggiore in 1949, Cornegliano in 1951, and Bordolano and Ravenna in 1952. Of particular importance was the discovery at Cortemaggiore since it was the first to produce oil in sufficient quantities for commercial exploitation. Either because of the "energy" famine from which Italy suffered from the dawn of the industrial revolution, or because the cost was especially advantageous in comparison with competing fuels, methane has profoundly influenced the nation's employment and income, accounting in 1954 for 11 per cent of all energy produced in Italy. Natural gas fields and pipelines in the Po Valley can be seen in the map reproduced herewith.

The success of A.G.I.P. prompted the Italian Government to present, and Parliament to approve, in 1953, a law creating Ente Nazionale Idrocarburi (E.N.I.) to control all the State's related interests, including A.G.I.P., in the hydrocarbon field. E.N.I. also has the task of promoting research, and of exploiting gaseous and liquid hydorcarbons as well as steam. It has, moreover, the exclusive right to prospect and exploit the oil and gas finds in the Po Valley. But in the rest of the country there prevails a system of free competition. E.N.I.'s balance sheet, for the first full year ended April, 1954, showed a profit of 2340 million lire. This State undertaking operates through the subjoined companies : A.G.I.P. Mineraria, which searches for, and produces, hydrocarbons ; S.N.A.M., which is responsible for the transportation of natural gas, such as construction and operation of pipelines, and A.N.I.C., which processes petroleum. E.N.I. holds a 51 per cent interest in A.N.I.C., which in turn has a 50 per cent interest in Stanic, and several other chemical concerns producing dyes, cosmetics, detergents, and resins. It has a further interest in the refining of crude oil through its control of R.O.M.S.A. and through A.G.I.P.'s 51 per cent holding in the Industria Raffinazione Olii Minerali refinery (I.R.O.M.), the balance being held by the British Petroleum Company, Ltd. A.G.I.P. is responsible for the distribution of oil products, including liquid gas, and it owns the E.N.I. group tanker fleet. Furthermore, E.N.I. has a 20 per cent share holding in Societa Termo-Elettrica Italiana (S.T.E.I.), which has built a methane-powered thermo-electric installation at Tavazzano, near Milan.

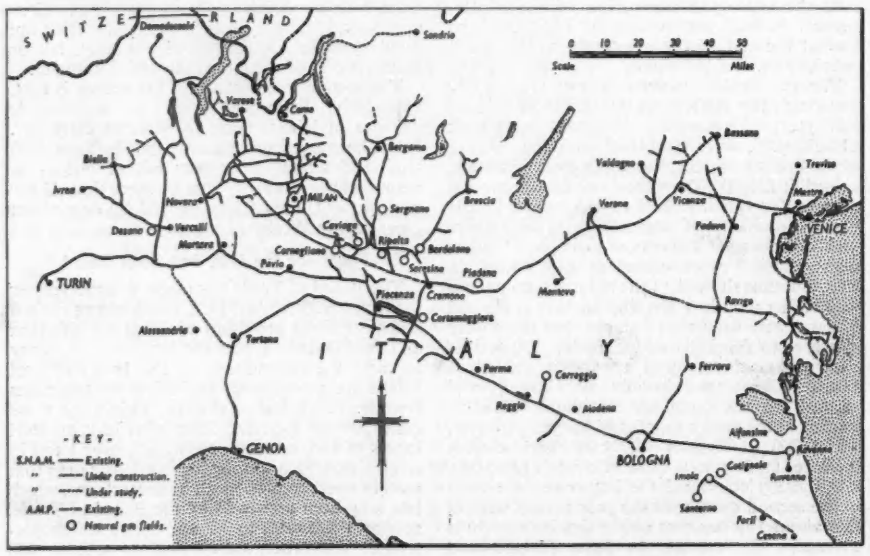
In 1954 A.G.I.P. Mineraria accounted for 95,000 million cubic feet of methane, a hundred-fold expansion compared with 1938, and between 1948 and the end of 1954 the S.N.A.M. gasline network was expanded from 416 miles to over 2300 miles. The daily capacity of these lines reached 700 million cubic feet in 1954. Hitherto natural gas had been mainly used for thermo-industrial purposes, 71 per cent ; electricity generation, 11·5 per cent ; domestic uses, 6·5 per cent ; chemical synthesis, 6 per cent, and road transport, 5 per cent. Early in 1955, 5,000,000 Italians were using liquefied petroleum gas. By reducing the price of natural gas by nearly 25 per cent, A.G.I.P. established itself in the market by the end of 1953, when A.G.I.P.G.A.S. was serving close on a million users. A year later bottled gas was supplied to 1,300,000 homes, and it is estimated that this figure will increase to 2,000,000 by the end of this year.

Apart from stepping up the consumption of methane and liquefied petroleum gas, E.N.I. has plans to expand and improve the utilisation of natural gas as a raw material for the chemical industry by converting methane through partial oxidation into hydrogen and acetylene and, thence, nitrogenous fertilisers and synthetic rubber. In a year or two a large chemical plant is to be completed, at Ravenna, with an annual production of 350,000 metric tons of synthetic rubber, and a similar tonnage of nitrogenous fertilisers. To foster scientific research and industrial utilisation of hydrocarbons, E.N.I. is erecting a large research and experimental station at St. Donato, near Milan which we illustrate opposite.

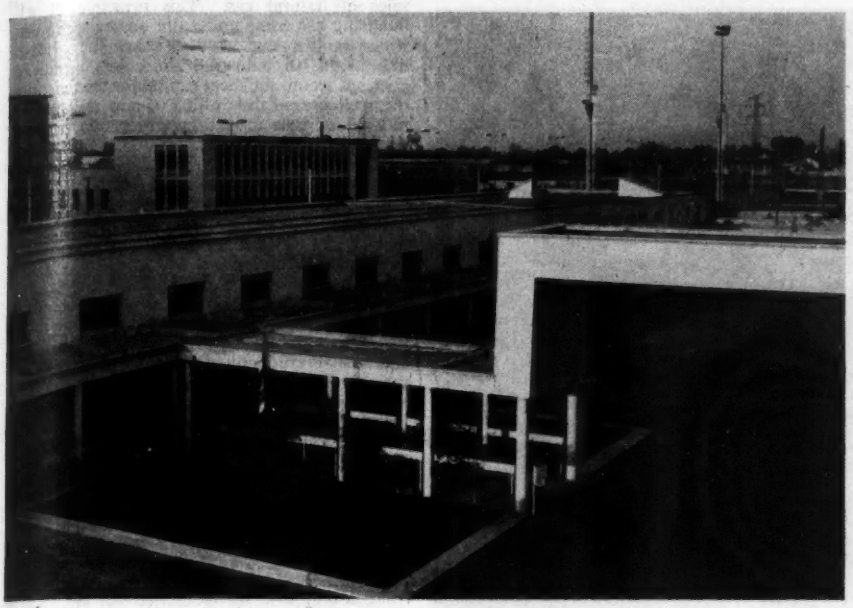
The Ferrara factory of the Montecatini Chemical Company represents Italy's pioneer undertaking in the production of chemicals from petroleum and natural gas. Construction commenced in 1950 and several units have already been commissioned. Whereas in the United States producers of ethylene concentrated on cracking gaseous feeds, mainly ethane and propane recovered from natural and refinery gases, European producers, urged by a lack of sufficiently large quantities of crackable gases, found it profitable to prepare ethylene from the heavier petroleum fractions. The Kellogg steam pyrolysis process was developed specifically for such feedstocks as naphtha and gas oil, since it possesses advantages in high yields without coking.

Like the Wilton Works of Imperial Chemical Industries, Ltd., the Montecatini company in Italy employs this Kellogg exclusive pyrolysis technique at its Ferrara chemical plant. It is designed for an eventual maximum capacity of 56,000,000 lb a year of C_2 and C_3 olefines, the production of the principal olefine derivatives being polyethylene 13,200,000 lb, polystyrene 17,600,000 lb, and acetone 12,000,000 lb per annum.

The Ferrara installation consists of a feed preparation section in which heavy naphtha and gas oil feedstock is distilled from crude petroleum, a steam pyrolysis section in which the feed is cracked at high temperatures, and a recovery section for separating ethylene and other olefine products. The production cycle is an integral one, starting with crude oil. The raw material is delivered by tankers at Porto Marghera, nearly 60 miles from the works ; it is stored at a coastal



Map showing natural gas fields and pipelines in the Po Valley



E.N.I. technical and economic laboratories near Milan

depot with a 220,000 barrel capacity, and later conveyed to the plant dock in tank lighters of 7000 barrels capacity. The crude oil is distilled for the preparation of the 4500 barrels per day charge of a unit, with an evaporating still, a topping column with two strippers alongside and a stabiliser for petrol. Of the four resulting products, petrol, naphtha, gas oil and fuel oil, the first is treated in the sweetening plant and the last utilised, in part, at the works for heating. The intermediate fractions, naphtha and gas oil, form the charge for the catalytic cracker which handles products with a distillation curve of 150 deg. to 350 deg. Cent. up to 2500 barrels per day. Here the charge is vaporised in a section of the stills, superheated steam is added, and it is cracked in the last section. The resulting products are cooled in the quench boilers, thus producing steam and from them they enter the flash column. This has a lateral stripper and fractionates the liquids into three items: the end tar, gas oil from the lateral stripper and petrol. The end tar is used in the works for heating and the heavy oil is used as a flow accelerator for heavy fractions. The cracked gas is compressed in the primary depropaniser, together with the cracked petrol. From the bottom of the column the depropanised petrol is passed on to the stabiliser and from its top the C_4 fraction is obtained. The top gases are taken off, treated with diethanolamine and soda, for removing sulphur compounds, dried on activated alumina and passed on to the catalyst unit for acetylene removal. With an acetylene content in the C_2 fraction of less than 100 parts per million, the gases are sent to the separator unit for obtaining the desired fractions. Our illustration shows the olefine plant compressor room.

The separator unit is designed on various columns in cascade, all operating at low pressure and at very low temperature. The tail gas from the top of the first column consists of a mixture of methane and hydrogen, the second column yields at the top the C_2 fraction and at the bottom the C_3 fraction. The C_2 fraction is separated into ethane, 95 per cent ethylene, and 99·5 per cent ethylene. The requisite low temperature for the column condensers is produced in four cycles by auxiliary refrigerators, employing, respectively, as refrigerants, propylene, ethylene and methane, according to the temperature of the condensers. Of these the first two are provided by the plant itself, which also restores the cycle losses, whilst methane comes from outside as natural gas. Particular attention was paid to the design of the low-temperature section of the plant, especially as regards choice of materials capable of withstanding such temperatures, and in the initial arrangements for drying the crude gas, as well as for inversion and de-icing of the appliances.

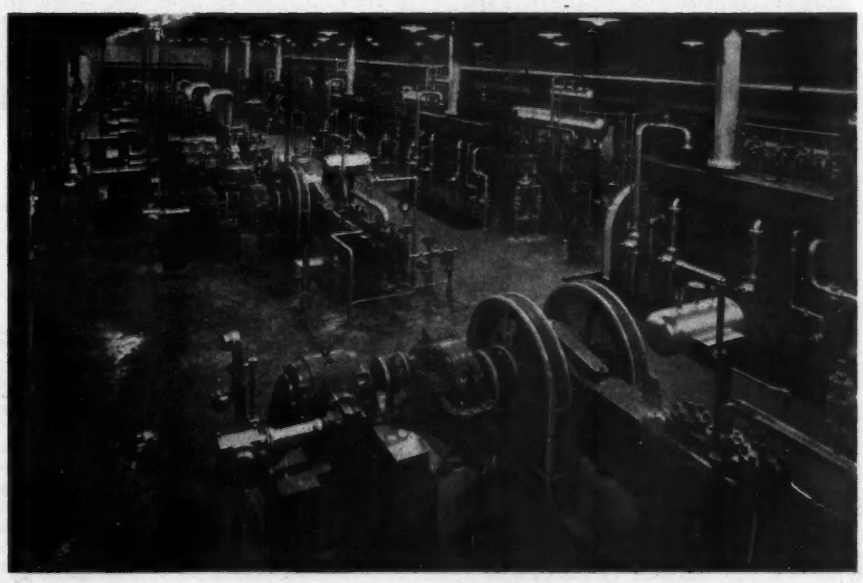
The cracked oil products are utilised as follows: the tail gas is used for works heating; the C_4 fraction is separated into its components—butadiene, butylene and butane—the first fraction being earmarked for further chemical applications; the C_3 fraction is used partly in the preparation of isopropanol by hydration, for conversion to acetone and in part for the production of superior alcohols for use in preparing plasticisers in an Oxo synthesis unit. A propylene-propane rectification unit provides for the recovery of the bottoms; the propylene from the top is recycled and propane from the bottom is sold as liquefied petroleum gas. The 95 per cent ethylene feeds units producing dichloroethane and dibromoethane by synthesis from the respective halogens, ethyl chloride by synthesis with anhydrous hydrochloric acid, monomer styrene by alkylation of benzol and subsequent dehydrogenation by catalysis and, finally, ethylene oxide for conversion into glycols. Part of the glycols are to be used in the production of "Terylene." Lastly, petrol from the cracking process goes through the same sweetening treatment as the primary gasoline.

The discovery of the Caviaga gas field by A.G.I.P. in 1946 marked a turning point in the nation's energy resources. Since the gas was at high pressure (160 atmospheres), the latest drilling and production methods had to be introduced. In 1954 nearly 100 new wells were drilled, the aggregate drilling depth being about 190,000m. In comparison with the preceding years, the total of exploratory wells rose, while that of productive ones went down. The Caviaga field consists of an anticline of Upper Miocene, capped by clayey Pliocene and sandy Quaternary formations. The productive zone is a highly porous arenaceous formation, with argillaceous intercalations, and at the top of the dome it is 150m thick. Reserves of this field are estimated at 10,000 million cubic metres of gas, consisting of dry, almost pure, methane.

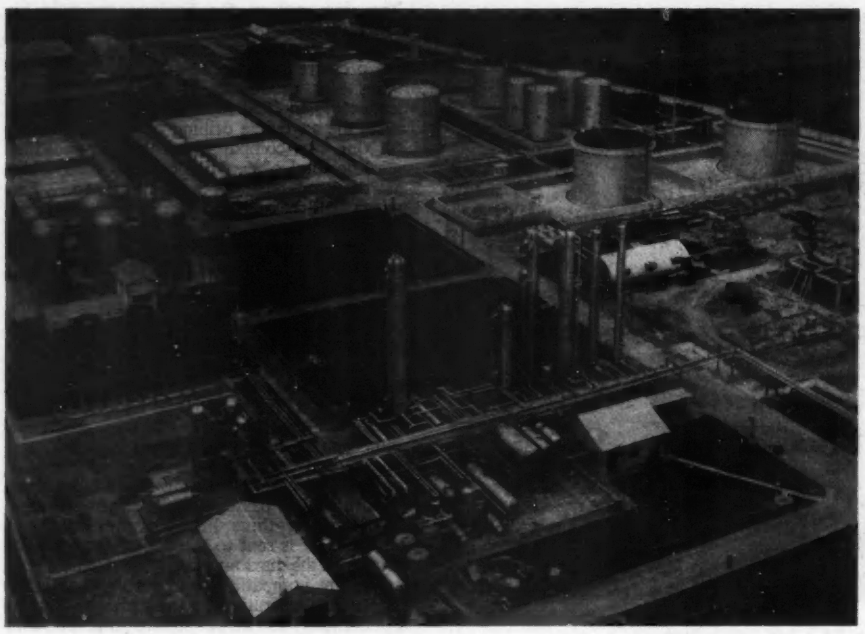
The degassing plant at Cortemaggiore which we show on page 314 was initially designed in 1950–51 to treat 3,000,000 cubic metres of gas daily to obtain premium motor spirit, liquefied gases (propane and butane) and a small quantity of residue (kerosine and gas oil). The gas, produced from forty-five wells, passes through five gathering centres serving three high-pressure collectors, from which it is sent to the degassing plant. It arrives with the maximum pressure and minimum temperature compatible with technical requirements of the operation of the gathering system (approximately 130 kg per square centimetre and 21 deg. to 22 deg. Cent.). Following expansion to 56 kg per square centimetre, the gas is dehydrated with diethylene glycol until it attains the dew point of −15 deg. Cent. Then it passes to the refrigeration plant, where it is cooled to between −6 deg. to −8 deg. Cent., after which it enters an absorption column for washing with a cooled light oil. The latter absorbs about 70 to 75 per cent of the propane contained in the crude gas, as well as the C_4s and C_5s. The table indicates the composition of the Cortemaggiore gas before and after treatment.

	Gas from the wells	Gas after treatment
Pressure, kilogrammes per square centimetre	130	55
Temperature, deg. Cent.	22	15
Calorific value, kg-cal. per cubic metre	9680	9320
	Percentage composition	
N_2	0·20	0·20
C_1	93·05	95·00
C_2	4·40	4·45
C_3	1·35	0·35
C_4	0·55	—
C_5	0·45	—

Thus, stripped of its most valuable components, the gas leaves the plant with a minimum calorific value of 9100 kg calories per cubic metre, and is



Olefine plant compressor room



A.G.I.P. Mineraria gasoline and liquefied petroleum gas plant at Cortemaggiore

forwarded to the distributing centres. The oil employed in the absorption process is first submitted to degasification, the by-product being a low-pressure gas, which is utilised as fuel in the plant itself. The oil then passes to the distillation unit, where the absorbed hydrocarbons are separated from the basic oil, and the residue from the fractionating tower collected from the bottom of the column is used in heat exchangers to preheat the oil passing into the distillation plant. At the end of the circuit, part of the lean oil is separated and sent back to the refrigeration plant to be reused for absorption ; the rest is pumped to the boiler, where it is heated to 320 deg. Cent. and evaporated to one-third of its volume. It is then returned to the distillation unit for use in preheating. In the process the presence of the oil vapours has the effect of stripping, thus dispensing with the use of steam.

The Cortemaggiore field has a large number of storage tanks and the usual network for their distribution, which is carried out partly by tank car, but also by an 8km pipeline to the depot at Fiorenzuola, where there is an installation for bottling the liquefied petroleum gas, and from which distribution is effected by rail.

Over and above the three horizons from which natural gas is produced, there are two at deeper levels, from which good quality crude oil of low sulphur content is extracted. A catalytic cracking unit with a capacity of 400 metric tons a day and designed to produce high octane gasoline, liquefied petroleum gas, and minor quantities of residues to treat this crude, is now operating.

Production of natural gas from the Po Valley in recent years is given below :—

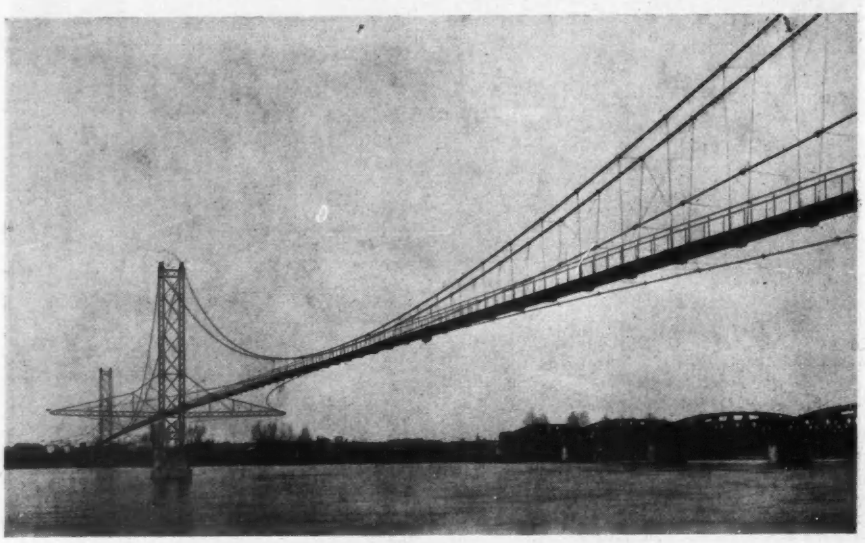
Year	A.G.I.P. (In 1000 cubic metres)	Other Companies* (In 1000 cubic metres)	Total
1938	1,719	15,392	17,111
1950	305,699	198,539	504,238
1952	1,179,106	258,792	1,437,898
1954	2,644,000†	300,000†	2,943,600

* Companies that had concessions before the passage of the 1953 law.
† Estimated.

The existence of these reserves of natural gas suggests that, at greater depth, oil may be found in quantity. In 1954, approximately 100,000 metric tons of 35 deg. A.P.I. crude oil were produced. A.G.I.P. had some thirty rigs in the area engaged in wider search in 1955, and exploration costs were financed from profits earned by sales of natural gas. This principle of self-financing has come under fire on the score that, whilst on the one hand it raises the price of natural gas to industrial consumers unduly, it does not secure sufficient capital for the extension of pipelines and the drilling of new wells. The rate of increase in natural gas production has declined in recent months, and E.N.I. is having recourse to investing in a large chemical industry to increase the profitability of natural gas to find the capital to search for more gas and crude oil. One of our illustrations shows part of the Cortemaggiore-Caviaga gas pipeline.

Production of natural gas in 1955 was estimated at 3500 million cubic metres and its consumption in chemical plants is expected to increase. But the marked rise envisaged in thermal-electrical stations hinges on recent spectacular crude oil discoveries in the Italian mainland. Products from domestic petroleum might well compete with methane gas in this field. This trend is also calculated to enhance the prospects of the use of natural gas in chemical synthesis and in domestic consumption.

(To be continued)



A section of Cortemaggiore-Caviaga 13in gas pipeline

Equipment of German Metal Goods Industries

According to a survey carried out last year in the metal goods industries, the technical equipment of the West German factories in this field was, on the average, behind that of similar establishments in the U.S.A., Canada, Great Britain, Sweden, Switzerland, and other countries. It was of the greatest importance, especially in the case of small and medium undertakings, to be able to bridge this gap gradually. In this connection, much stress was to be laid on writing off equipment by fixed percentage on the reducing balance each year, rather than in a linear fashion. The law relating to the depreciation of buildings also required improvement, since out-of-date buildings often impeded the production efficiency.

It is stated that in 1954 for the industries in question the book value of equipment per employee was about DM.2700, whereas present-day factories require investments of the order of DM.10,000 to DM.15,000 per worker, or even more. The low book value indicated that much equipment had been written off and so must be considered as being out-of-date. It also meant that modernisation out of current depreciation was not possible.

The age distribution of machine tools, according to the survey which has been mentioned, is as follows :—

	Per cent
Over 20 years old	40
10–20 years old	30
Under 10 years old	30

In relation to the number of employees in the various factories, the position is that the smallest factories have the oldest machine tools.

The position with regard to equipment other than machine tools is said to be equally unsatisfactory. Of this class 29 per cent is more than twenty years old, 34 per cent is between ten and twenty years old, and only 37 per cent is newer than ten years. The overall position is stated to be as follows :—

No. of employees in factory	Percentage of equipment in each group which is		
	(*a*) Over 20 years old	(*b*) Between 10–20 years	(*c*) Under 10 years old
1–9	68·1	17·6	14·3
10–19	60·0	18·4	21·6
20–49	56·8	22·4	20·8
50–99	41·0	29·0	30·0
100–199	34·2	40·2	25·6
200–499	34·4	32·7	32·9
500–999	32·0	33·2	34·8
1000 or over	33·0	29·5	37·5

International Congress on Guided Missiles

It is announced that the Association pour l'Encouragement à la Recherche Aéronautique, and the Association Européenne pour la Recherche et les Applications des Fusées et Engins/Guidés, will hold a joint congress at Paris, from December 3 to 8, 1956. Simultaneously there will be an exhibition of rockets, guided missiles, and associated equipment. Those interested are asked to write to the first-named society at 1, Rue de Courty, Paris (7e).

Sea Water Evaporators at the Morro Bay Steam Power Station

BY OUR AMERICAN EDITOR

The recently completed Morro Bay steam power station of the Pacific Gas and Electric Company at Morro Bay on the southern California coast presents an interesting application of multiple-effect evaporation to produce fresh water from the sea. The power station comprises two 156·25MW turbo-generators and two boilers each generating 1,135,000 lb of steam per hour. The initial evaporators are guaranteed to convert 50 gallons per minute of sea water into water of less than 50 p.p.m. total solids content. Boiler make-up water is obtained from a high-purity evaporator which increases the water purity to less than 1 p.p.m. solids content.

AMONG the many site requirements for a steam power station is a reliable source of fresh water for boiler feed water make-up and general use in the station. It sometimes happens that other site considerations such as availability of land and condenser cooling water, satisfactory foundation conditions, ease of electrical interconnection to the grid system, accessibility of highways or railways and suitable delivery for fuel are satisfactory; but an adequate supply of fresh water presents a problem. This situation existed at Morro Bay on the southern California coast when the Pacific Gas and Electric Company planned the construction of a power station.

The Morro Bay power station is situated on the northern shore of Morro Bay near the entrance from the larger Estero Bay, on the Pacific Ocean coast in San Luis Obispo County, and is adjacent to the north-western edge of the town of Morro Bay. The property, consisting of approximately 140 acres, is separated from the bay by a 180ft strip of county property on which is situated the Embarcadero road and a county pier. Circulating water is pumped from the intake structure on the shore of Morro Bay through concrete pipes under the Embarcadero to the power station building. It discharges through a concrete tunnel, approximately 3000ft long, into Estero Bay on the north side of Morro Rock. Fuel oil is delivered by tankers anchored in Estero Bay through a submarine pipeline to four large storage tanks. Power generated by the station is delivered through two 230kV transmission lines to the Gates substation, where it ties into the company's 230kV transmission grid serving central and southern California. There also is a 115kV transmission line which connects the Morro Bay station to the San Luis Obispo substation.

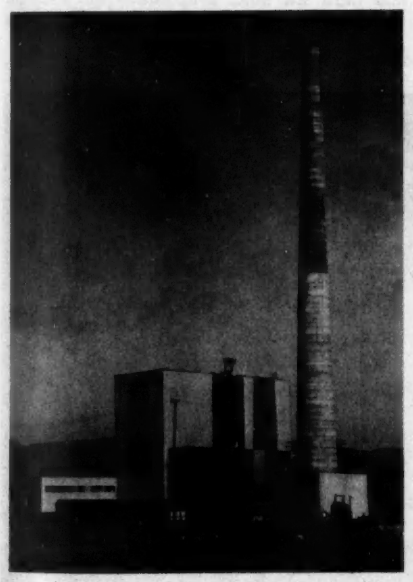


Fig. 1—Morro Bay steam power station in California, showing aluminium sheet wall construction

The main power station building is 148ft high, 263ft long and 183ft wide. It is built on a reinforced concrete mat 5ft thick, the top of which is 12ft below ground level, and the building is completely enclosed by aluminium sheet. The office building, the warehouse and the machine shop adjoin the main building on the west side. The station contains two generating units, each of which includes a boiler, a turbo-generator and the necessary auxiliary equipment.

Each radiant boiler comprises a main steam drum, a two-stage superheater, a reheater and a two-section economiser. The boiler is designed to generate 1,135,000 lb of steam per hour at 1850 lb per square inch gauge pressure and burns 10,440 U.S. gallons of oil per hour at this load. Fuel is injected through fifteen oil burners. The boilers are designed to operate on gas and coal as well as oil, although gas and coal handling facilities have not been provided at this time.

The turbines, which are illustrated in Fig. 2, are twenty-one-stage, tandem-compound, triple-flow, reheat units operating at 3600 r.p.m. Steam at 1800 lb per square inch gauge and 1000 deg. Fah. enters the turbine and partially expands through the high-pressure section. It is then reheated to 1000 deg. Fah. in the reheater section of the boiler before completing its expansion through the intermediate and low-pressure elements of the turbine. Each turbine is guaranteed to pass 1,080,000 lb of steam per hour and is rated at 150MW. The generators are two-pole, three-phase, hydrogen-cooled units rated at 183,824kVA at 0·92 power factor with 30 lb per square inch hydrogen pressure. Each generator contains eight coolers in which the hydrogen is cooled by water. The d.c. exciter is driven by the generator through a reduction gear at 1191 r.p.m. and is rated at 375kW.

The radial-flow condenser receives 98,600 gallons of sea water per minute. The condensed steam is collected in the hotwell situated underneath the condenser shell. Two condensate pumps remove water from the condenser hotwell and deliver it to the boiler feed water pumps. Each of the two nine-stage pumps has a capacity of 2400 gallons per minute at 825ft head and is capable of removing all of the water from the condenser hotwell at full load. The second pump starts automatically if the operating pump fails.

Fresh Water Requirements

The amount of fresh water required for the two generating units, including some margin, was determined to be 100 gallons per minute. Of this amount, about 2 to 3 gallons per minute are required for drinking and sanitary use. Of the remainder, approximately half is used for boiler make-up and the rest for general utility purposes. For emergency fire fighting, fresh water will be taken from the 500,000 gallons standpipe situated on the bluff above the power station with sea water being used as a back-up.

The first source of fresh water investigated was the local municipal water supply of Morro Bay and vicinity. Except for the small amounts of drinking and sanitary water required at the station, the local supply could not be made available for this installation. The next source of water investigated was wells on the property. There were two wells on the property when it was purchased. Because of the proximity of the wells to the ocean, there is the possibility that they may become contaminated with salt water if they are pumped too heavily. In this region, where the rainfall is light and in cycles, the wells were not considered adequate to give an assured water supply. However, they are being used for general utility purposes to the extent of their capability. The Morro Bay steam power station is situated at the mouth of Morro Creek, but this creek did not have a good dam site and it was decided to study the water flow in Toro Creek, which is in the next major watershed to the north. The cost of construction of a dam across Toro Creek, including the necessary relocation of roads and petroleum pipe lines to avoid the reservoir, made this alternative source of water more expensive than sea water evaporators.

The next method studied was the use of sea water evaporators to produce fresh water. The capital expenditure involved was less than the

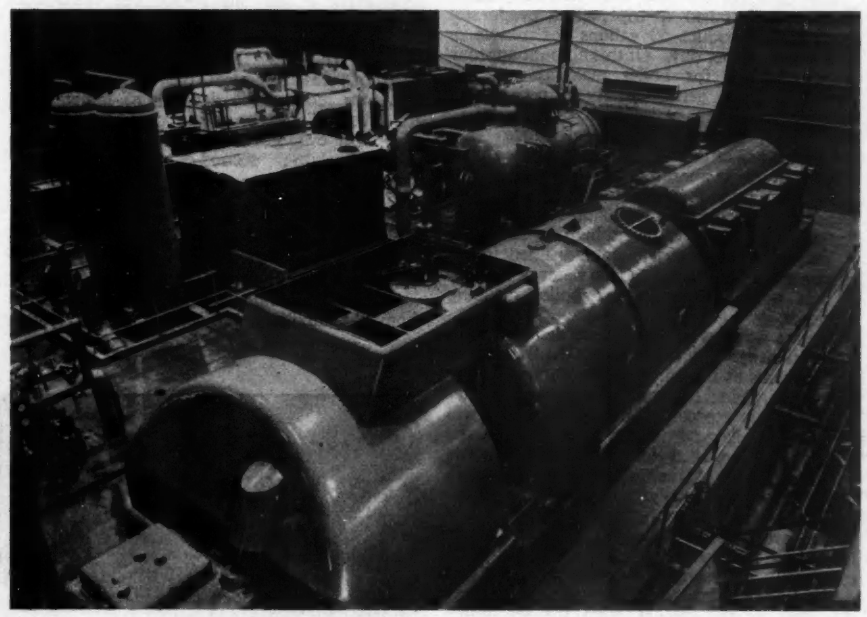
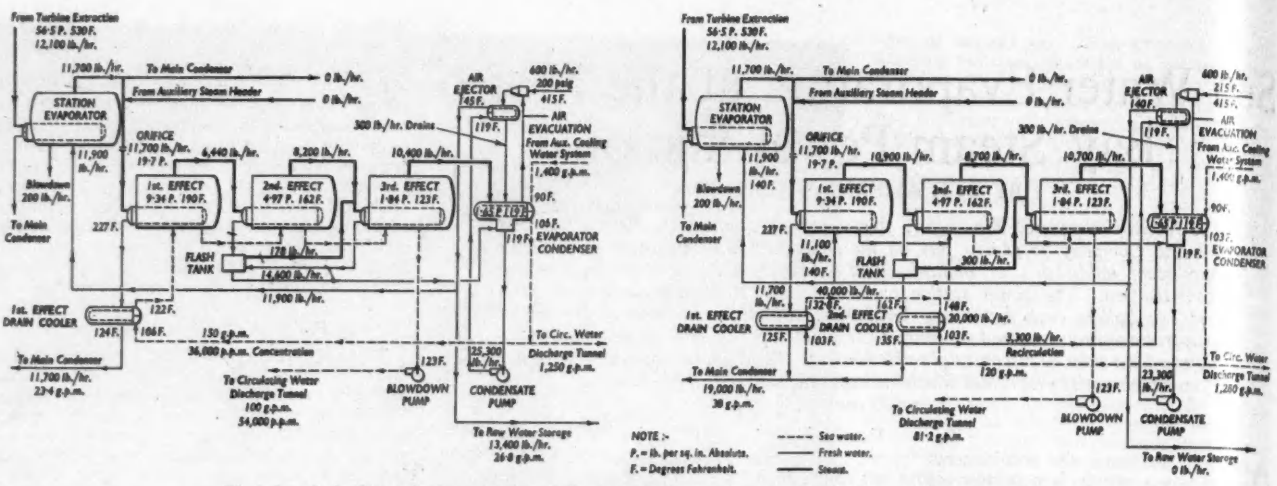


Fig. 2—Power station interior, showing one of two 156·25MW turbo-generators



Figs. 3 and 4—Flow diagram showing (left) three-effect evaporation and (right) two-effect evaporation

cost of the above-mentioned reservoir, and because of this lower cost it was decided to install sea water evaporators to produce fresh water for the first two generating units of the power station. The original specifications for the evaporator system were determined by engineers of the Pacific Gas and Electric Company, and the final system was designed jointly by the engineers of the Pacific Gas and Electric Company and the Bechtel Corporation, who were the constructors of the station.

For each of the first two generating units there was installed a triple-effect evaporator designed to produce 50 gallons per minute or 72,000 gallons per day. Of this amount approximately half is for boiler make-up and the remainder is for general utility purposes. The drinking and sanitary water is being obtained from the local water system of Morro Bay. As about half of the water to be produced from the sea water evaporators need not be of the purity required for boiler make-up, it was decided to specify that the solids content of the water produced could be as high as 50 p.p.m. A part of this water is then redistilled in the station evaporators to produce water of a purity of less than 1·0 p.p.m. for boiler make-up purposes.

The sea water evaporators were designed to be of sufficient capacity to supply all the fresh water requirements as though the wells were not available, thus giving the station an assured water supply. It is expected normally that there will be water available from the two wells on the property to be used for utility, standby fire fighting and miscellaneous water purposes. In this case the sea water evaporators will only have to supply the make-up requirements for the station evaporators. The water from the wells is too hard for direct feed to the station evaporators and would require water treatment. It was decided not to install a water treatment plant at this time, as the effluent from the sea water evaporators is satisfactory for direct feed to the station evaporators.

Evaporator Cycle

Three principal methods of operation of the sea water evaporator are used at Morro Bay : (1) condensate effluent from the sea water evaporators is used for station evaporator make-up as required and the remainder pumped to the 500,000-gallon standpipe to be used for general utility puposes. During periods of large boiler make-up requirements part of the steam vapour from the station evaporators is routed to the main condenser and only sufficient steam is supplied to the first-effect sea water evaporator to generate the water required for station evaporator make-up. (2) All condensate effluent from the sea water evaporators is used as make-up to the station evaporator. (3) All condensate effluent from the sea water evaporators is used as a supply to the standpipe. This case is infrequent and means that boiler make-up is not required. Live steam is used as there is no vapour supply from the station evaporators.

Three-Effect Evaporation

As illustrated in Fig. 3, the steam for the heating tubes of the first effect of the sea water evaporator is the vapour from the station evaporator normally, but also can be supplied through reducing valves from the auxiliary steam header. The condensate from the first-effect evaporator tubes drains down through the first-effect drain cooler to the main station condenser, where it becomes a part of the boiler feed water. The vapour or steam from the first-effect evaporator is the supply for the third-effect evaporator. The vapour from the third-effect evaporator is condensed in an evaporator condenser. The pressure in each vessel is a partial vacuum, which reduces the temperature and therefore reduces the deposits of minerals on the tubes. The pressures at rated capacity are : first-effect evaporator shell, 9·34 lb per square inch absolute ; second-effect, 4·97 lb per square inch absolute ; third-effect, 1·84 lb per square inch absolute ; and in the evaporator condenser, 1·65 lb per square inch absolute. This high vacuum in the evaporator condenser is maintained by means of a two-stage twin-jet air ejector.

The make-up water for the evaporators comes from the auxiliary salt-water cooling system after the water has gone through the cooling water heat exchangers ; 1400 gallons per minute of sea water flows through the evaporator condenser, 150 gallons per minute of which is fed to the first-effect evaporator through the first-effect drain cooler. The sea water passes through the succeeding effects and 100 gallons per minute leave the third-effect evaporator as blowdown at the rated evaporator output of 50 gallons per minute. The concentration of solids is increased 50 per cent from 36,000 to 54,000 p.p.m. Because of the high vacuum in the evaporator a blowdown pump is used to pump the brine to the condenser discharge tunnel. The remainder of the cooling water from the evaporator condenser is also discharged to the discharge tunnel. Starch and boiler compound are introduced into the sea water make-up to the sea water evaporator to modify the mineral deposits on the tubes so that they are more easily removed.

Two-Effect Evaporation

As illustrated in Fig. 4, in this case the first-effect sea water evaporator is used as a station or high-purity evaporator and only the second and third sea water evaporators are used for generating steam from the sea water. The reason

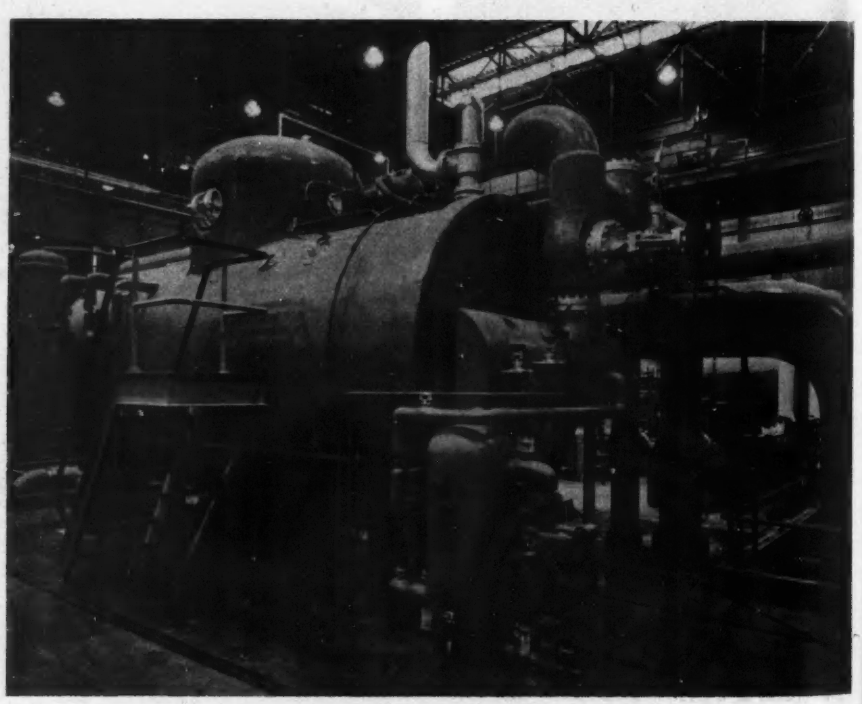


Fig. 5—Three-effect sea water evaporator plant at Morro Bay

for this arrangement is to give a balance between the new water generated and the steam required to generate it. In the previous method 2·2 times as much fresh water is made as steam supplied. As in the three-effect method, the vapour from the station evaporator generates steam from the first-effect sea water evaporator. However, the make-up water supplied to the shell is the 50 p.p.m. effluent obtained from the second and third-effect sea water evaporators. With this feed water it is possible to obtain steam with a purity of 2 p.p.m. Combining this effluent from the station evaporator thus gives a combined water purity of about 1 p.p.m.

The vapour from the first-effect evaporator supplies the second-effect evaporator and drains through a second drain cooler to the main condenser. In order to keep the make-up water requirements in balance with the steam generated part of the drains from the second-effect evaporator heating tubes are combined with the effluent from the sea water evaporator condenser after first passing through the second-effect drain cooler.

Finally, it is possible to operate the plant using three-effect evaporation with live steam. In this case the process in the sea water evaporators is the same as in the original method. The difference is that live steam, supplied from the auxiliary steam header connected through reducing valves from the boiler, is the source of heating steam to the first-effect of the sea water evaporators.

As shown in Fig. 5, the sea water evaporators are situated in the turbine room on the intermediate floor level 13ft above the ground floor level. The "high purity" station evaporator is situated on the turbine floor level 26ft above the ground floor. The evaporator condensate pumps and blowdown pumps are situated on the ground floor directly below the evaporator condenser. The auxiliary salt water pumps which supply the cooling water for the evaporator condensers and the feed water for the evaporators are situated in the screen house on Morro Bay; 1400 gallons per minute of sea water are pumped in a 10in line through the cooling water heat exchanger to the sea water evaporators. The sea water evaporator system and other heat exchanger equipment were manufactured by the Lummus Company, of New York City.

Costs of Evaporator System

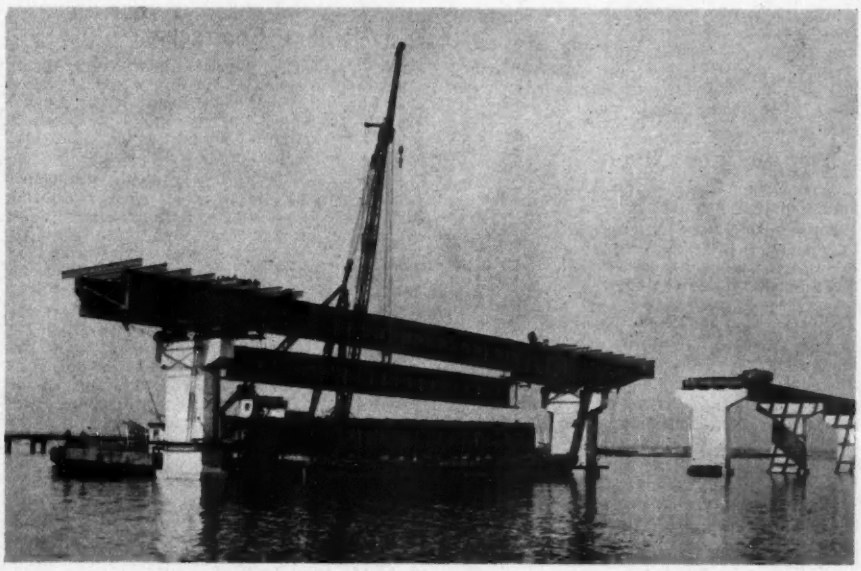
Because of the considerable interest shown recently in methods of obtaining fresh water from the sea to supplement other supplies available, a note about the cost of producing the water at Morro Bay is of interest. Assuming a current American fuel oil cost of 1·75 dollars per barrel, a 100 per cent rated load on the evaporators, and steam extraction from the turbine, the cost per 1000 gallons of water is estimated to be 1·96 dollars. This includes the annual fixed charges on the capital costs of the sea water evaporator equipment, costs of equivalent power loss from turbine extraction, chemical treatment and auxiliary pumping. No charge has been included for labour, as no additional labour is required above the normal complement of operators in the power station. If auxiliary live steam from the boilers is used the cost per 1000 gallons is estimated to be 2·58 dollars. It is interesting to compare these costs with the various water costs listed below :—

	Cost per 1000 gallons, dollars
Irrigation water at 10 dollars per acre-foot... ...	0·031
Water from an average irrigation pumping plant in California...	0·017
San Francisco municipal water at an average rate of 1000 gallons per minute	0·247

Without the sea water evaporator method, it would be necessary to add to the above costs the expense of treating the raw water to make it a suitable supply for the station evaporator. In addition to the water treating plant, it also would be necessary to install an evaporator condenser for condensing the steam from the station evaporator. Assuming that the well water was used at Morro Bay, the cost for treating an average flow of 56 gallons per minute is estimated to be 0·93 dollars per 1000 gallons. This cost includes the fixed charges together with the operating and maintenance costs for the water treating equipment. The use of sea water evaporators at Morro Bay demonstrates that it is possible to build a power station on the seashore if the site is desirable but does not have fresh water. While a method has not been found for producing fresh water from the sea which is economical for agricultural use, the above application indicates that the evaporator method is attractive for power station water requirements.

Erection of Great Egg Bay Bridge Superstructure

The Bethlehem Steel Company, of Bethlehem, Pennsylvania, recently saved considerable time in erecting the Great Egg Bay Bridge by forgoing the use of a travelling derrick crane and falsework in putting up heavy girder and beam spans. Instead, all the sections were set by a derrick boat having a 75-ton capacity stiffleg derrick with a 43ft mast and 90ft boom, which is shown in the accompanying illustration. Further erection time was saved by the use of high-strength bolts as field fasteners of the beam spans, 4600 bolts being used in the structure. Lying just west of Ocean City, New Jersey, the bridge was the last of the 282 bridges of the Garden State Parkway to be completed.



Erection of 128ft long girders of the Great Egg Bay Bridge in New Jersey, using a derrick boat

The method employed was first to erect the short pier girder sections, most of which were 56ft long. These sections were balanced on rocker or fixed shoes upon the concrete T-piers and were temporarily braced with ⅞in diameter wire rope guys with turnbuckles. At the base of the piers the guys were attached to a rectangular steel frame which enveloped the pier. On each end of the pier a steel column was used under the pier cap to prevent the bracing frame from rising. Since the pier caps have sloping surfaces on the underside, a short section of broad-flange beam was used with two 1¼in diameter tie rods, 18ft long, to hold the columns in place. Before the erection of the 128ft long middle girders, the pier girders were adjusted to the proper slope so that the side entry of the middle girders into the splice was possible. When both the middle girders were in place and pinned and bolted to make them continuous between the piers, the bracing and floor steel were erected.

The girders are 9ft deep and the heaviest hoisted by the derrick boat weighed 63 tons. The piers range in height from 26ft to 45ft above mean water. A second lighter derrick boat was used to set up the bracing frames on the piers. This boat had a 16-ton stiffleg derrick with a 24ft mast and a 70ft boom. Besides the bridge, only 3 miles of the northbound lane just south of Great Egg Bay now remain to be paved before the completion of the entire 165-mile parkway, which extends from Cape May to Paramus, near Ridgewood, New Jersey. The parkway is operated by the New Jersey Highway Authority.

Semi-Conductor Resistivity Test Set

A test set designed to measure the resistivity of semi-conductors has been introduced by Baird Associates Inc., 33, University Road, Cambridge 38, Mass. It covers a range of resistivity from 0·1 to 100 ohm-cm, with a measurement accuracy of ±5 per cent. It is specially designed for measuring the resistivity of germanium sample, but the probe assembly can be adapted for the measurement of silicon.

The test set, which is designated "JN1," makes use of the "four-point-probe" method for measuring semi-conductor resistivity. Four electrodes in a line are placed in contact with the face of the material to be tested. A known current is passed through the sample between the outer electrodes. The resulting floating potential across the inner electrodes is proportional to the resistivity of the sample. To eliminate any disruption of the normal voltage and current gradients surrounding the electrodes, a null method is used. A potentiometer with a d.c. null detector is connected to the inner probes : when the detector is balanced the bucking voltage is equal to the floating potential across the inner probes and, therefore, proportional to the resistivity of the sample.

The "JN1" set consists of three separate pieces of equipment : the probe assembly, "JP1," germanium resistivity test unit, "JQ1," and the null detector. The probe assembly contains four tungsten probe points on ground steel slides in ground steel ways, backed by an "Elastomer" block. The probe carriage is driven up and down by a gear-head motor. Spring-loaded electrodes, reproducible loading and uniform approach rate make possible highly reproducible results.

The germanium resistivity unit, "JQ1," provides a source of fixed current for the outer electrodes of the probe assembly. Coarse and fine adjustment of the current from the isolated, internal-battery source are provided in addition to metering. A timing circuit prevents overheating of the sample. The "JQ1" unit also provides a source of measuring potential from a highly regulated supply. This voltage is adjustable by means of a precision multi-turn potentiometer. Resistivity is read directly from the final potentiometer setting.

Personal and Business

Appointments

MR. W. O. BELL has been appointed production director of Black and Decker, Ltd., Harmondsworth.

MR. F. W. MCCARTNEY has been appointed assistant general manager of Black and Decker, Ltd., Harmondsworth.

DR. G. B. B. M. SUTHERLAND will take up his appointment as director of the National Physical Laboratory on September 14th.

DR. H. W. MELVILLE, F.R.S., has taken up his appointment as secretary of the Department of Scientific and Industrial Research.

AVELING-BARFORD, Ltd., Grantham, announces the appointment of Mr. G. M. Warren as local director and member of the board of management.

MR. D. R. LOVE, B.Sc., A.M.I.E.E., has been appointed manager, Dominions division, of Metropolitan-Vickers Electrical Export Company, Ltd.

MR. HANDEL DAVIES has been appointed Deputy Director-General of Aircraft Research and Development (Future Systems), in the Ministry of Supply.

HUNTINGTON, HEBERLEIN AND CO., Ltd., announces that Mr. J. R. Wingfield has been appointed a director of the company ; he retains his position as company secretary.

MR. J. A. H. LEES has been appointed naval architect for new construction for the British and Commonwealth Group of the Union-Castle Mail Steamship Company, Ltd.

THE BRITISH INDIA STEAM NAVIGATION COMPANY, Ltd., announces the appointment of Mr. Harold Byers as Commodore Chief Engineer Officer of its fleet with effect from August 3rd.

MR. O. T. EVANS, Assoc. M.C.T., A.M.I.Mech.E., A.M.I.E.E., has been appointed assistant chief engineer (mining), electrical general engineering department, Metropolitan-Vickers Electrical Company, Ltd.

MR. S. F. FOLLETT has been appointed Head of the Ministry of Supply Staff at the British Joint Services Mission in Washington in succession to Mr. S. Scott Hall, C.B. This appointment will take effect in October.

MR. H. CLIFFORD WILLIAMS, M.I.Struct.E., has been appointed representative of the mechanical handling and colliery engineering division of Humphreys and Glasgow, Ltd., within the South Western Division of the National Coal Board.

CATERPILLAR TRACTOR COMPANY, Ltd., announces that with the acquisition of the Birtley Company, Ltd.'s factory, Colonel R. T. Edwards, formerly managing director of the Birtley Company, Ltd., remains as manager of the factory and joins the board of directors of Caterpillar Tractor Company, Ltd.

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION announces that Dr. J. Pearson is now in charge of the Sheffield Laboratories. Mr. E. W. Voice becomes responsible for control of the chemistry department, Mr. R. Mayorcas has been appointed deputy head of the steelmaking division, Mr. J. G. Wistreich has become head of the mechanical working division. Mr. S. S. Carlisle, head of the South Wales laboratories, becomes deputy head of the division. Mr. E. A. Oldfield has been appointed senior research officer of the Cutlery Research Council, and Dr. J. Pearson has been appointed consultant to the File Research Council.

Business Announcements

C. S. ALLOTT AND SON, has opened a London office at 20/22, Bedford Row, W.C.1 (telephone, Holborn 1691/2).

ALFRED HERBERT, Ltd., Factored Division, Red Lane Works, Coventry, announces that it has been appointed sole selling agent in the United Kingdom for Gildemeister automatics.

MIDLAND SILICONES, Ltd., announces that arrangements have been made for the additional distribution of silicone electrical insulating compound "MS4" by the British Central Electrical Company, Ltd., 6 and 8, Rosebery Avenue, London, E.C.1.

THE CRITTALL MANUFACTURING COMPANY, Ltd., announces that it has joined the Arcon Group. Existing members of the group are I.C.I., Ltd., Stewarts and Lloyds, Ltd., United Steel Companies, Ltd., and Taylor Woodrow (Building Exports), Ltd.

BRISTOL AIRCRAFT, Ltd., announces the formation of a new furnishing department to design, plan and co-ordinate work on the interior furnishing of Britannia airlines. Mr. A. G. L. Langfield has been appointed manager and Mr. Donald Diamond designer.

TUBE INVESTMENTS, Ltd., announces the formation of a new subsidiary, the British Cycle Corporation, Ltd., to take over and control the manufacturing resources of its constituent bicycle companies situated in the Birmingham area. These are Armstrong Cycles, Ltd., Brampton Fittings, Ltd., Hercules Cycle and Motor Company, Ltd., Phillips Cycles, Ltd., and Walton and Brown, Ltd.

BLACK AND DECKER, Ltd., announces that it has set up an international division to co-ordinate and intensify the development of markets outside the U.S. and Canada. Mr. Robert Appleby has been appointed director of international operations of the Black and Decker Manufacturing Company, Towson, Maryland, U.S.A., while retaining his present position as director and general manager of the English company.

Contracts

DECCA RADAR, Ltd., has received an order for its harbour radar type 32 from the Southampton Harbour Board for installation at the Board's Calshot signal station. The set will give cover from King George V drydock to No Man's Land Fort, in the East Solent, and to Gurnard Head in the West Solent.

BRISTOL AIRCRAFT, Ltd., is to supply "Sycamore" helicopters to the value of several million pounds for service with the German Defence Forces. The "Sycamore" is a 4/5-seat aircraft with an Alvis "Leonides" engine. Deliveries will begin in 1956 and the helicopters will be in service by the following Spring.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has received from Norges Vassdrags Og Elektrisitetsvesen an order for two 50MVA, 428 r.p.m., vertical waterwheel generators for extensions at Rossaga, a power station on the fringes of the Arctic Circle. These generators will supply power to an iron works and an aluminium works near the power station.

THE ENGLISH ELECTRIC EXPORT TRADING COMPANY, Ltd., has received a second order for two three-phase, outdoor forced oil-cooled type transformers, rated at 170MVA, 17·1kV/161kV, for the Tennessee Valley Authority's Johnsonville steam plant at Tennessee. A previous order was placed with English Electric earlier this year for two similar transformers for the same station, and the total value of the two orders is approximately 1,000,000 dollars. All four transformers are to be designed and manufactured at the Stafford works of The English Electric Company, Ltd.

THE BRITISH AND COMMONWEATLH SHIPPING COMPANY, Ltd., has ordered from the Greenock Dockyard Company, Ltd., two refrigerated cargo ships to be named "Rotherwick Castle" and "Rothesay Castle." Each ship will have a length of 493ft by 65ft 6in breadth, by 34ft 11in depth, and be propelled by a Harland and Wolff six-cylinder diesel engine The same builder has received orders for three 10,000-ton deadweight cargo liners, each fitted with a five-cylinder Doxford oil engine. Three oil tankers having a length of 530ft by 72ft beam by 30ft depth, a deadweight of 18,000 tons and each powered by a six-cylinder Doxford oil engine of 6400 b.h.p., have been ordered from John Brown and Co. (Clydebank), Ltd.

Miscellanea

LIGHTWEIGHT TRAINS FOR MERSEY LINES.—The first of twenty-four new three-car train sets to replace the former Mersey Railway vehicles has been placed in service between Liverpool Central and New Brighton, and others will be introduced after the necessary tests. The new trains are generally similar in design to the Wirral electric stock introduced by the former L.M.S.R. They are of lightweight design and are of all-steel construction.

DIESEL MAINTENANCE DEPOT AT STRATFORD.—Work has begun on the construction of a new maintenance depot for diesel multiple-unit trains and locomotives at Stratford, Eastern Region, British Railways. The depot is designed for the maintenance of diesel multiple-unit trains and shunting locomotives, but it will also be used to service some of the initial allocation of main line diesel locomotives to the Eastern Region under the British Railways modernisation plan.

REGISTRAR OF RESTRICTIVE TRADING AGREEMENTS.—Mr. Rupert Leigh Sich has been appointed Registrar of Restrictive Trading Agreements and a registrar's office has been opened at Chancery House, Chancery Lane, London, W.C.2 (Chancery 2858). The registrar will be responsible for preparing, compiling and maintaining a register of restrictive trading agreements, and for taking proceedings before the Restrictive Practices Court in respect of the agreements on the register.

PORTABLE POWER POINT FOR ELECTRIC TOOLS.—In order that two industrial portable electric tools or other electrical appliances can be operated simultaneously and at a distance from a convenient source of power, a portable power point equipment has been introduced by Wolf Electric Tools, Ltd., Hanger Lane, London, W.5. The unit consists of a cable drum mounted on a stand with a pair of built-in 13A, three-pin, ring main, insulated and shuttered flush sockets. The sockets are connected to a terminal block mounted in the centre of the drum which accommodates 100 yards of 23/0·0076in, three-core T.R.S. cable.

DEVELOPMENT OF NATURAL RESOURCES.—We are informed that the Hunting group of companies has formed a subsidiary company—Hunting Technical Services, Ltd.—which will be engaged in carrying out surveys on which development schemes can be based. The technical staff of the company will include specialists in agriculture, soils, forestry, geology and ecology, and will include a comprehensive aerial surveying and mapping organisation. The work of the company is briefly explained in a brochure entitled "Ninety-Two Million More Mouths to Feed," in which the significance of such work, in a world whose population is rapidly increasing, is stressed.

IMPERIAL COLLEGE EXPANSION.—The Imperial College of Science and Technology has announced the appointment of Richard Sheppard and Partners as architects for the expansion scheme in Princes Gardens. The north, east and south sides of the Gardens, which lie east of Exhibition Road, South Kensington, and about 100 yards from College buildings, have recently been acquired. It is hoped to proceed immediately with the development of the east and south sides. New halls of residence, to include about 480 study bedrooms, will be provided in a new building on the east side and in half of a new building planned for the south side. The remainder of the building on the south side will provide certain common room and refectory facilities originally planned for the central College site, but transferred to Princes Gardens under the revised building plans which allow the Collcutt Tower to be retained as a free-standing campanile.

SMOKE DENSITY METER.—A new smoke density meter, introduced by Bailey Meters and Controls, Ltd., Progress Way, Croydon, Surrey, is primarily designed for use in small installations where the sighting heads are set not more than 15ft apart on the opposite walls of a chimney or duct. The projector has a cast iron housing in which a low voltage lamp is positioned at the focus of a condenser lens to project a beam of light across the chimney into the lens system of the receiver head. In the receiver the light is focused on to a photo-cell which generates an electric signal depending upon the intensity of the light. The photo-cell transmits a maximum signal of the order of 10mV to an indicator unit, which consists of a moving coil galvanometer fitted with a scale calibrated to give readings of percentage obscuration. An alarm unit can be fitted into the indicator, if required, and a continuous chart recorder to provide a permanent record of smoke density will shortly be available for the instrument.

AIR STRIPS IN USE.—Scottish Aviation, Ltd., Prestwick, Ayrshire, has produced a book of photographs illustrating the ability of aircraft to use landing strips less than a furlong in extent. Ground and air views of prepared fields in Malayan jungle and Himalayan mountain territory illustrate graphically the improbable sites that can be exploited. The book likens the air strips to aircraft carrier decks, and they frequently end in an almost vertical hillside, giving no choice of flight direction. In the jungle there is the additional hazard of high turbulence in hot and steamy valleys ; in some cases trees have to be cleared from ridges at a distance from the strip to improve the approach. Sketches appear of the "Prestwick Pioneer," seen in many of the photographs, the "Twin Pioneer" and a "Turbo-Pioneer," a cantilever high-wing monoplane with one undercarriage retracting into the twin engine nacelles. Having a pay load of 10,000 lb, it is shown with a crawler tractor driving up the ramp under the rear of the fuselage. It retains to some extent the high ground angle of the piston engine aircraft, there being two "tail" wheels in front of the upswept aft fuselage.

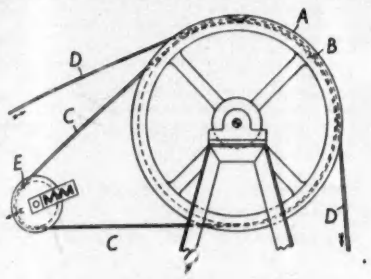
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

POWER TRANSMISSION

754,678. July 1, 1954.—IMPROVEMENTS TO PULLEYS, Dynamit Actien-Gesellschaft vormals Alfred Nobel and Co, of Troisdorf, Köln, Germany.

The invention relates to a coating or a lining for cable, pulleys and the like, such as are used especially in conveying machines and conveyor installations in mines or in other transport plant. As the drawing

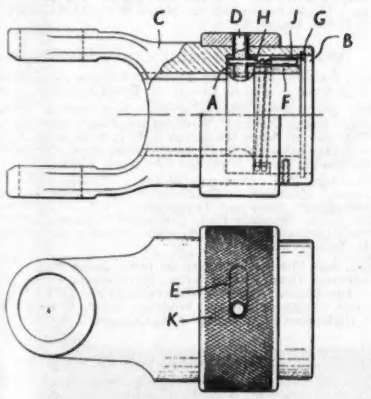


No. 754,678

shows, in the groove *A* of the driving pulley *B* an endless belt *C* serving as coating runs under a driving belt *D* and is held in the tensioned state by a spring-loaded roller *E*. In order to be able to place the endless belt *C* on the driving pulley during operation the flange *G* is recessed at *H* on one side of the pulley to a point near the bottom of the groove profile. Belt insertion is further facilitated by the mounting of the tension roller *E*. If desired, the recess *H* can be fitted with a removable fitting piece. Another driving pulley shown in the specification is provided with an aluminium lining, in which a profile belt, serving as coating, rotates.—*August* 8, 1956.

754,886. June 29, 1954.—TAKE-OFF SHAFT COUPLINGS, Jean Walterscheid, Gertrud Walterscheid née Buchhalz, Bernhard Walterscheid-Muller, Eduard Orthen and Kurt Schroter, all trading as Jean Walterscheid, of Siegburg, Germany.

As shown in the drawing of the coupling, an annular locking ring *A* is rotatably mounted in a widened bore *B* formed in coupling element *C*. Rotation of the ring is limited by a pin *D* engaging



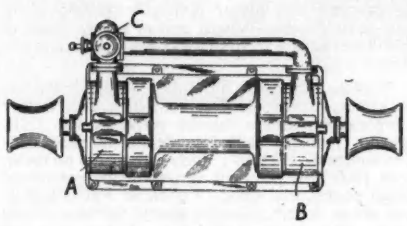
No. 754,886

transverse slot *E* in the coupling element. A bush *F* in conjunction with a clamping ring *G* supports the locking ring. A spiral spring *H* has its ends bent over at right angles and is supported with one of the ends in an aperture *J* in the bush *F* and with the other end in a hole in the locking ring *A*. The second spring end also engages a transverse bore in the pin *D* to secure it in the bore in the ring *B* to limit its turning movement in slot *E*. A further ring *K*, rotatably mounted on the outside of the tubular element *C*, is connected to the locking ring by one or more pins. Coupling and uncoupling are facilitated by this outer ring. If desired, the bush *F* may be connected to the coupling element by locking pins. It is advantageous to provide the inner surface of the locking ring *A* with a profile conforming to the take-off stub shaft, and to round off the raised portions to correspond to the annular groove. The coupling element is then axially well supported with slight play on the take-off shaft. In use, when the outer rotatable member is turned in one direction, against the action of the spring, the raised portions align with the splines on the tubular part, so that it can be positioned on to the stub shaft so that the raised portions align with the circumferential groove. When the rotatable member is released the spring turns it and aligns the raised portions with the splines on the stub shaft to lock the coupling on the stub shaft.—*August* 15, 1956.

CRANES AND LIFTING APPLIANCES

754,211. October 22, 1952.—HYDRAULIC TRANSMISSION SYSTEMS FOR DRIVING WINCHES, Hydraulik A/S, Brattvaag, near Aalesund, Norway. (*Inventor: Hans Vestre Huse.*)

The invention relates to a winch, as shown in the drawing, driven by a hydraulic power transmission system in which two motor circuits, consisting of



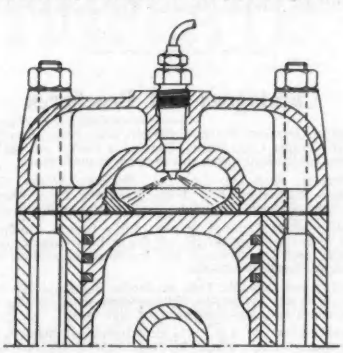
No. 754,211

two separate hydraulic motors *A* and *B*, are keyed or coupled one to each end of the winch drum shaft. A single control valve *C* operated by a hand-lever serves to control the supply of hydraulic fluid from the pump to the respective motors in such a way that as the supply to one motor increases, that to the other motor decreases. The motors are coupled to each other in parallel in the main hydraulic circuit. —*August* 8, 1956.

INTERNAL COMBUSTION ENGINES

755,086. October 5, 1954.—CYLINDER HEAD FOR DIESEL ENGINES, Société Anonyme Adolphe Saurer, Arbon, Switzerland.

The invention relates to a cylinder head for diesel engines with spray injection having a combustion space contained in the head, the space being constricted at its juncture with the cylinder space. This



No. 755,086

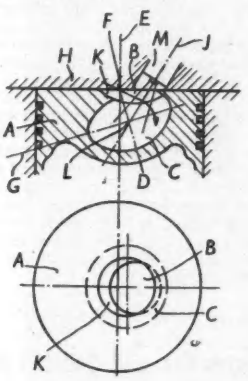
cylinder head can be either welded or brazed; cast, or a combination of these production processes. As the drawing shows, the cylinder head has an insert ring located in the combustion space in heat conducting relation with the cylinder head and shaped so as to restrict the combustion space at its junction with the cylinder space. The insert ring is formed of a bronze which combines the following physical characteristics: heat conductivity, 45 to 90 per cent of that of pure copper; tensile strength, 45 kg to 75 kg per square millimetre; breaking elongation, 7 to 15 per cent. The cylinder head is cast in a light metal alloy with the insert ring attached to the cylinder head in the casting process. In another form the insert ring is screwed into the cylinder head, or as shown in the above drawing, the cylinder head material can be rolled over the outwardly bevelled edge of the ring in order to secure it.—*August* 15, 1956.

754,870. April 29, 1954.—COATINGS FOR PISTONS AND PISTON RINGS, General Motors Corporation, Grand Boulevard, Detroit, Michigan, U.S.A. (Assignees of James DeWiley Fleming and Arnold Odell DeHart).

According to the invention, pistons or piston rings for internal combustion engines have a thin, hard and tough coating of polytetrafluoroethylene. Tests on pistons coated with polytetrafluoroethylene indicate that they can be used over greatly extended periods of time under normal operating conditions without detrimental effects on the heat-stable polytetrafluoroethylene coating. Coated pistons in test engines which have been run for approximately 10,000 miles and at the end of that period examination showed that the friction-reducing coating was still intact. The antifriction properties of polytetrafluoroethylene coated pistons were also tested in a friction test engine and compared with uncoated pistons. The results of such tests showed that use of pistons which were coated resulted in an average of approximately 4 per cent less engine friction than conventional, uncoated pistons used in the same engine under similar conditions. The thicknesses of the various coatings and the manner of applying them and sintering them is fully detailed and described in the specification. A drawing (not reproduced herewith) shows the area of piston and ring which can be coated in accordance with the specification.—*August* 15, 1956.

755,144. May 17, 1954.—FUEL INJECTION, Motoren-Werke Mannheim A.-G., formerly Benz Abt. Stat. Motorenbau, Carl-Benz-Strasse 5, Mannheim, Germany.

The invention relates to internal combustion engines with a combustion chamber in the piston so that when a single-hole or pintle-type nozzle is used, even with high-speed vehicle diesels having a small



No. 755,144

swept volume, fuel consumption values are obtained which have heretofore normally only been obtained with much larger and slowly running engines. As will be seen from the drawing, in the piston *A* of an internal combustion engine, a cylindrical air inlet aperture *B* leading to the combustion chamber *C* has the form of an ellipsoid of rotation around the minor axis of the generating ellipse. The ellipse generating this rotational solid has a minor axis *D*, which is inclined relatively to the piston axis *E* and which intersects the latter at a point *F* in a plane containing the upper surface of the piston. The minor axis *D* and the major axis *G* of the ellipsoid are preferably in the ratio of 2 : 3. In the cylinder head *H* the injection nozzle is so arranged outside the central axis of the cylinder that the axis *J* of the injection nozzle is inclined relatively to the cylinder axis *E* and extends in a common plane with the latter. The axis of the cylindrical wall *K* of the inlet aperture *B* extends as shown perpendicular to the fuel jet axis or axis *J* of the injection nozzle. It is also preferable to arrange for the axis of the cylindrical wall of the inlet aperture *B* to extend parallel to the minor axis *D* of the ellipsoid. The cross-section limited by the wall of the inlet aperture is smaller than the greatest cross-section of the ellipsoid in the direction of the major axis, preferably in the ratio of 1 : 3·5. The centre point *L* of the combustion chamber *C* is located, relatively to the cylinder axis, on that side of the piston on which the injection nozzle *M* is located. The inlet aperture is arranged on that side of the combustion chamber which is nearer the nozzle. During the compression stroke of the piston the combustion air arrives in the combustion chamber with a substantially uniform flow which is perpendicular to the fuel jet and passes over the entire width of the chamber so that maximum mixing of air and fuel is ensured. The position of the axis of the cylindrical

inlet aperture with respect to the axis of the injection nozzle ensures that the hot combustion gases issuing from the combustion chamber through the aperture are deflected past the injection nozzle so that it is protected from overheating.—*August* 15, 1956.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

CLASSIFICATION OF INSULATING MATERIALS FOR ELECTRICAL MACHINERY AND APPARATUS

No. 2757 : 1956. Price 4s.—For many years information on the classification of electrical insulating materials has been given in appendices to those British Standards in which reference is made to the insulation of windings. Most of these appendices were based on the 1935 edition of Publication No. 34 of the International Electrotechnical Commission, "I.E.C. Recommendations for Rotating Electrical Machinery." The classification given in this publication came to be very widely adopted for all types of electrical machinery and apparatus, and for this reason it was recently agreed in the I.E.C. to publish a completely revised classification as a separate I.E.C. Recommendation.

The classification now published as B.S. 2757 is, for all practical purposes identical with the draft I.E.C. document prepared at Philadelphia in 1954, which represents the concensus of international opinion on the subject. Three new Classes E, F and H are introduced and the former Class O has been redesignated Class Y. The basis of the new classification is not the chemical composition of materials, but rather their ability to withstand the temperatures assigned to their class. These temperatures are stated and a general description of each class is given. There is an appendix which gives guidance on the classification of a number of particular insulating materials.

The new classification has become necessary because of the development of new materials and manufacturing processes, and it is intended that the numerous appendices dealing with classification of insulating materials which now appear in the various British Standards for electrical machinery and apparatus should eventually be withdrawn and superseded by reference to the new classification. It should be noted, however, that the temperature rise specified in any particular standard need not in every case be such as to bring the maximum total temperature to that assigned to a particular class of insulation in this classification. Moreover, the introduction of the new Classes E, F and H will not necessarily lead to the adoption of all of them in the revision of existing British Standards.

Launches and Trial Trips

MISSOURI, oil tanker ; built by Harland and Wolff, Ltd., for the Texas Company (Panama), Ltd., New York ; length between perpendiculars 600ft, breadth moulded 84ft, depth moulded 44ft ; deadweight 28,000 tons ; thirty oil cargo compartments, one main and one auxiliary pump rams ; one set of double-reduction geared turbines, 12,500 s.h.p. ; two oil-fired water-tube boilers supply steam at 600 lb per square inch, 840 deg. Fah.

KAITUNA, cargo liner ; built by Alexander Stephen and Sons, Ltd., for the Union Steam Ship Company of New Zealand, Ltd. ; length 325ft, breadth 50ft, depth 26ft, deadweight 5300 tons ; three cargo holds, derrick complement includes one to lift 25 tons ; electric winches ; Stephen-Sulzer single-acting, diesel engine, six cylinders, 600mm diameter by 1040mm stroke, 2410 b.h.p. at 128 r.p.m., overload power 3000 b.h.p. at 150 r.p.m. Trial, July 12th.

HOROMYA, oil tanker ; built by Hawthorn Leslie (Shipbuilders), Ltd., for Shell Tankers, Ltd. ; length overall 557ft, breadth moulded 69ft 3in, depth moulded 39ft, deadweight 18,000 tons ; thirty-three oil cargo tanks, one main cargo pump room, four vertical centrifugal turbine-driven cargo pumps ; two 550kW, 450V, 60 c/s turbo-alternators, one 200kW, 450V diesel-driven alternator ; one set of double reduction geared turbines, 8250 s.h.p., steam supplied at 500 lb per square inch and 800 deg. Fah. by two Foster Wheeler "D" pattern boilers. Trial, July 19th and 20th.

QUO VADIS, trawler ; built by Chantiers et Ateliers Augustin Normand for Ropert-Engelhardt ; length overall 37·40m, breadth moulded 7·20m, depth 4·05m, draught 3·38m, displacement 430 tons ; speed 12 knots ; one Duvant diesel engine, 750 h.p. Launch, July 24th.

BEN SCREEL, trawler ; built by John Lewis and Sons, Ltd., for R. Irvine and Sons, Ltd. ; length between perpendiculars 120ft, breadth 25ft, depth 12ft 6in ; electric trawl winch to take 1000 fathoms of 2¾in warp, fish room 7000 cubic feet, Mirrlees "K.S.S.6" diesel engine, 712 b.h.p. at 220 r.p.m. Launch, July 26th.

ALVENUS, oil tanker ; built at Walker Naval Yard by Vickers-Armstrongs, Ltd., for the Alvion Steamship Corporation ; length between perpendiculars 640ft, breadth moulded 86ft 6in, depth moulded 46ft 3in, deadweight 32,000 tons on 34ft draught, service speed 14¾ knots ; thirty cargo oil tanks, one main cargo pump room ; two 600kW turbo-generators, one 150kW and three 50kW diesel-driven generators ; one set of double reduction geared turbines, 13,750 s.h.p., two Babcock and Wilcox boilers. Launch, August 2nd.

CORSEA, collier ; built by Hall Russell and Co., Ltd., for William Cory and Son, Ltd. ; length between perpendiculars 320ft, breadth moulded 46ft, depth moulded 22ft 4in, deadweight 4600 tons ; five holds, three 75kW diesel-driven generators ; Clark-Sulzer single-acting, two-stroke diesel engine, six cylinders, 1300 b.h.p. at 162 r.p.m. Launch, August 2nd.

WINGA, raised quarter deck cargo ship ; built by Alexander Hall and Co., Ltd., for the Clydesdale Shipowners Company, Ltd. ; length between perpendiculars 275ft, breadth moulded 44ft, depth to upper deck 19ft 9in ; steam deck machinery, one 3-ton and eight 5-ton derricks ; one 25kW steam-driven generator, one 15kW diesel-driven generator ; Christiansen and Meyer double compound steam engine, two oil-fired Scotch boilers supply steam at 220 lb per square inch and 600 deg. Fah. Launch, August 7th.

EVGENIA NIARCHOS, oil tanker ; built at Barrow by Vickers-Armstrongs, Ltd., for the Neptune Tanker Corporation ; length between perpendiculars 725ft, breadth moulded 97ft 2in, depth moulded 52ft, deadweight 47,150 tons ; thirty-three cargo oil tanks, four 1000 tons per hour turbine-driven centrifugal cargo pumps, trial speed 17 knots at 36ft draught ; one set of double reduction geared turbines, 18,000 s.h.p., take steam at 600 lb per square inch and 860 deg. Fah. Launch, August 8th.

KUMALLA, cargo and ore carrier ; built by Henry Robb, Ltd., for the Union Steam Ship Company of New Zealand, Ltd. ; length between perpendiculars 235ft, breadth moulded 45ft, depth moulded to upper deck 15ft 3in, deadweight 1645 tons on 13ft 3in mean draught, trial speed 11 knots ; two holds, 90,000 cubic feet, electric winches, six 5-ton derricks ; three 75kW diesel-driven generators ; British Polar "M.58 M" two-stroke diesel engine, 1280 b.h.p. at 250 r.p.m. Launch, August 8th.

CAPETAN CARDAMILITIS, shelter deck cargo ship ; built by The Burntisland Shipbuilding Company, Ltd., for the Tramp Chartering Corporation of Panama ; length between perpendiculars 445ft, breadth 62ft 4½in, depth moulded to shelter deck 32ft, draught 27ft 11in, deadweight 11,750 tons ; five holds, ten 10-ton derricks, electric winches ; three 150kW diesel-driven generators ; Kincaid, two-cycle, single-acting, diesel engine, seven cylinders, 620mm by 1870mm combined stroke. Trial, August 9th.

Catalogues and Brochures

NORTON GRINDING WHEEL COMPANY, Ltd., Bridge Road East Welwyn Garden City, Herts.—Illustrated leaflet, dealing with the range of diamond wheels this company manufactures.

MARSHALL, SONS AND CO., Ltd., Britannia Works, Gainsborough.—Publication No. 2970, describing the "Marshall M.P.6" diesel wheeled tractor designed for large-scale cultivation.

CALMIC ENGINEERING COMPANY, Ltd., Crewe, Cheshire.—Leaflet No. 15, giving details of the A.L.A. vacuum drying apparatus used for drying at low temperatures without being affected by climatic conditions.

A. M. LOCK AND CO., Ltd., Prudential Buildings, 79, Union Street, Oldham, Lancs.—Provisional data sheet dealing with smoke meter and alarm designed by this firm.

ISOCRETE COMPANY, Ltd., 124, Victoria Street, London, S.W.1.—Brochure dealing with "Isocrete" sealed-cell lightweight concrete designed for thermal insulation of concrete roofs, terraces, ground and top floors, &c.

FOSTER TRANSFORMERS, Ltd., South Wimbledon, London, S.W.19.—Leaflet No. Fm12, giving details of the range of transformers, test equipment and voltage regulating equipment manufactured by this company.

STANDARD TELEPHONES AND CABLES, Ltd., Oakleigh Road, New Southgate, London, N.11.—Leaflet dealing with rocking armature receivers and transmitters, types 4041 and 4042 receivers and type 4103 transmitter.

AUTOMATIC TELEPHONE AND ELECTRIC COMPANY, Ltd., Strowger House, Arundel Street, London, W.C.2.—Leaflet dealing with "PMBX" private manual branch exchange, giving details of its operating and constructional features.

JOHN FOWLER AND CO. (LEEDS), Ltd., Hunslet, Leeds, 10.—Brochure describing the Fowler "Challenger 2" diesel crawler tractor, designed to meet the demand for a general-purpose tractor for both heavy agricultural and medium industrial duties.

GEORGE KENT, Ltd., Luton, Bedfordshire.—Publication No. TP5006/456, entitled "Instrumentation and Automatic Control of Open-Hearth Furnaces," describing recent examples of automatic-control schemes applied to open-hearth furnaces in this country and abroad.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Mon., Sept. 3rd.—LEEDS BRANCH : E.L.M.A. Bureau, Leeds, "Fire Prevention," R. French, 7.30 p.m.——N.E. LONDON BRANCH : Angel Hotel, Ilford, "The Work of the Association," H. E. J. Butler, 7.30 p.m.——SHEFFIELD BRANCH : Royal Victoria Station Hotel, Sheffield, Chairman's Address, followed by discussion on social activities, 7.30 p.m.

Wed., Sept. 5th.—GLASGOW BRANCH : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, Film, "Steam," 8 p.m.——MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, "Management in Industry," 7.30 p.m.——N. LONDON BRANCH : "Queen's Head," 677, Green Lanes, Harringay, N.4, "Electricity in Cable Making," G. H. Clowes, 7.45 p.m.——PRESTON BRANCH : R.A.F.A. Club, East View, Preston, "Electrical Accessories," E. Gouch, 7.30 p.m.

Thurs., Sept. 6th.—S. LONDON BRANCH : Half Moon Hotel, Broad Green, Croydon, Branch Lecturettes, 8 p.m.

Fri., Sept. 7th.—LIVERPOOL BRANCH : Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, 2, Chairman's Address, F. T. Bartho, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Sept. 26th.—LONDON BRANCH : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Some Aspects of Transistor Progress," H. W. Loeb, 6.30 p.m.

CORNISH ENGINES PRESERVATION SOCIETY

Sat., Sept. 8th.—Camborne, Annual General Meeting.

INCORPORATED PLANT ENGINEERS

Mon., Sept. 3rd.—BIRMINGHAM BRANCH : Imperial Hotel, Temple Street, Birmingham, "Fan Engineering," 7.30 p.m.

Tues., Sept. 4th.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, Strand, W.C.2, "The Maintenance of Lancashire and Economic Boilers," J. H. Williams, 7 p.m.

Wed., Sept. 5th.—LEICESTER BRANCH : Bell Hotel, Leicester, "Planned Maintenance," A. F. R. Stedman, 6.30 p.m.

Mon., Sept. 10th.—DUNDEE BRANCH : Mathers Hotel, Dundee, "The Application of Work Study and Incentives to Maintenance," D. Gardiner, 7.30 p.m.

Tues., Sept. 11th.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, Chairman's "At Home," 7.15 p.m.

Wed., Sept. 12th.—SOUTHERN BRANCH : Visit to Wilton House and Carpet Factory, 2.30 p.m.——WESTERN BRANCH : Grand Hotel, Bristol, "Ventilation and Air Conditioning," J. R. Kell, 7.15 p.m.

INSTITUTE OF PETROLEUM

Wed., Sept. 19th.—26, Portland Place, London, W.1, "Diesel Combustion Study by Infra-Red Emission Spectroscopy," W. T. Lyn, 5.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Sept. 10th.—Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, Chairman's Address, Informal discussion on "Design," 7.15 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Sept. 26th.—GENERAL MEETING : Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, Presidential Address, J. F. B. Vidal, 5.30 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Thurs., Oct. 11th.—Weir Lecture Hall, 10, Upper Belgrave Street, London, S.W.1, "Scale Effect Experiments on Victory Ships and Models," Part II, "Analysis of Wake Measurements on a Model Family and the Model Boat," D. C. Endert, Jr., J. D. van Manen, 4.45 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Tues., Sept. 4th.—COVENTRY GRADUATE SECTION : Craven Arms, High Street, Coventry, Douglas D. David Award, 7.15 p.m.

Wed., Sept. 12th.—DUNDEE SECTION : New Imperial Hotel, 15, Tally Street, Dundee, "Materials Handling : With Particular Reference to Batch Production," W. P. Kirkwood, 7.30 p.m.——EDINBURGH SECTION : North British Hotel, Princes Street, Edinburgh, Ladies' Night and Film Show, 7.30 p.m.

Mon., Sept. 17th.—COVENTRY SECTION : Craven Arms, High Street, Coventry, "Development of German Transfer Machines," Film and Discussion, 7 p.m.——MANCHESTER SECTION : Reynolds Hall, College of Technology, Sackville Street, Manchester, "CO_2 Process Applied to Core Making," A. Talbot, 7.15 p.m.

Wed., Sept. 19th.—BIRMINGHAM SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, Film Evening, "Automation," 7 p.m.——WOLVERHAMPTON GRADUATE SECTION : Technical College, Wulfruna Street, Wolverhampton, "High-Speed Press Work," J. A. Grainger, 7.30 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., Oct. 11th.—The Temple, Dale Street, Liverpool, Presidential Address, W. Rose, 7 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Fri., Sept. 7th.—FAWLEY SECTION : Copthorne House, Fawley, Hants, "Instruments in the Steel Industry," W. Swinn, 7 p.m.

Tues., Sept. 25th.—MAIN MEETING : Manson House, Portland Place, London, W.1, Presentation of the Bowen Prize. "The Accurate Calibration of Flowmeters," E. A. Spencer and A. T. J. Hayward, 6.30 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

Fri., Oct. 19th.—39, Elmbank Crescent, Glasgow, Symposium on the Application of Low-Alloy Steels for Welded Pressure Vessels, 10 a.m.